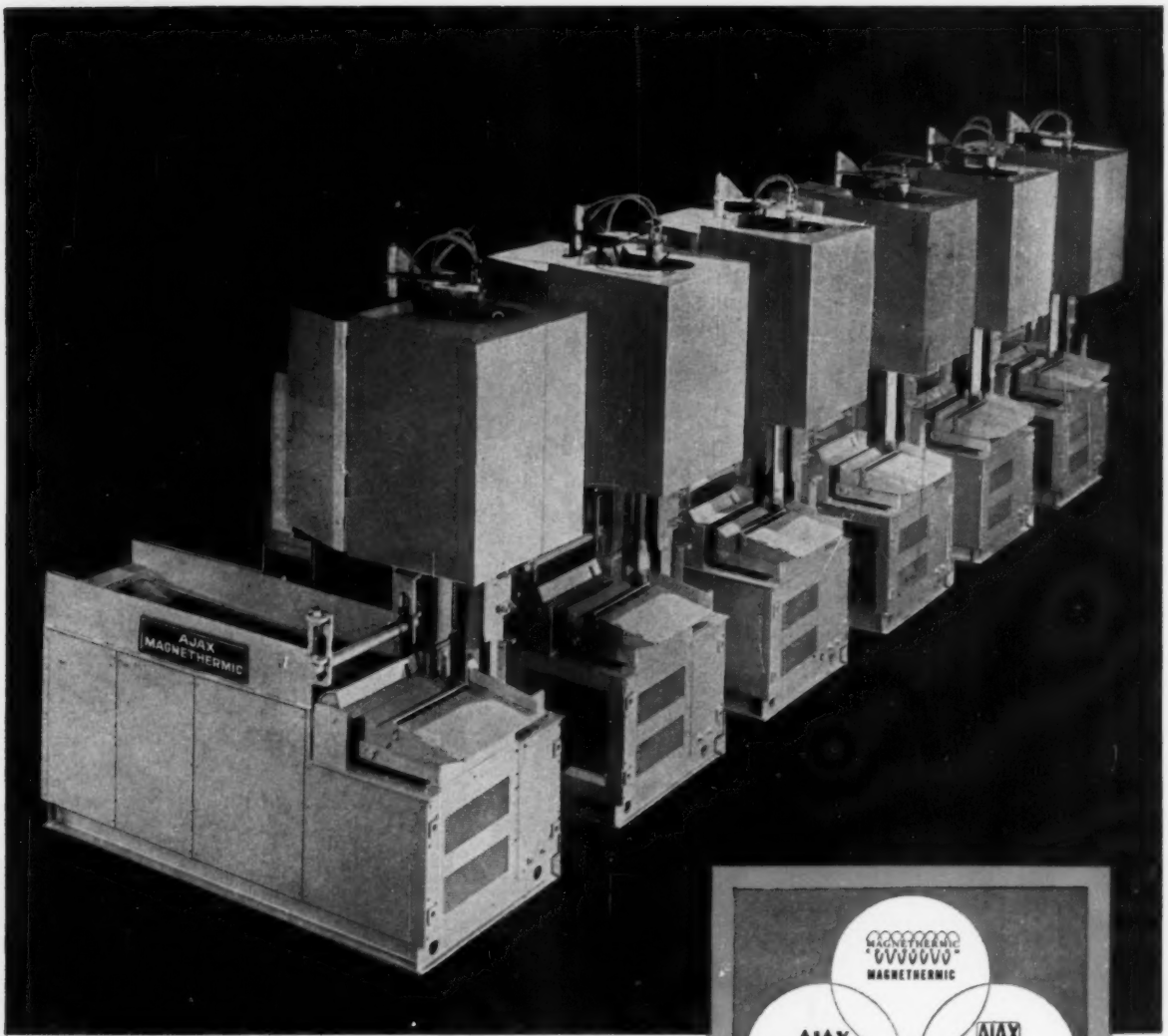
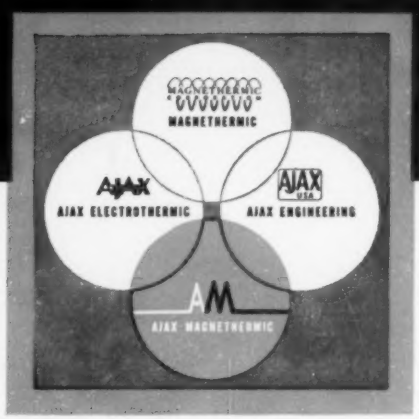


These six 400 KW vertical Billet Heaters heat stainless steel billets—5" —10" dia. x 28" long, to 2300° F at the rate of 12,000 lbs. per hour.



WATCH AM

FOR THE NEW IDEAS IN HEATING AND MELTING BY INDUCTION

Vertical Steel Billet Heaters, one of many products of AM, for the heating or melting of metals by Induction.

"induction heating is our only business"

AJAX Magnethermic CORPORATION

GENERAL OFFICES
P. O. BOX 839
Youngstown 1, Ohio

TRENTON DIVISION
930 Lower Ferry Road
Trenton 5, New Jersey

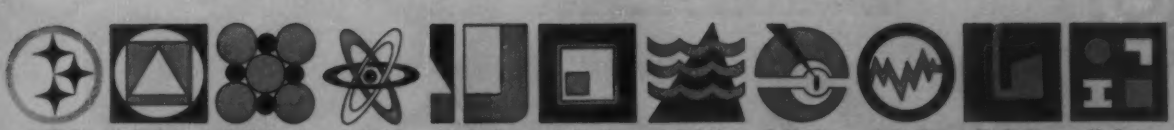
YOUNGSTOWN DIVISION
3990 Simon Road
Youngstown 1, Ohio

Circle 1681 on Page 48-E

METAL SHOW ISSUE
Metal Progress
OCTOBER 1960

42 NATIONAL METAL EXPOSITION and CONGRESS

A List of Exhibitors, the Technical Programs, and an Admission Invitation to the Show



EXHIBITORS

The Exhibitors at the Metal Show are classified into 11 areas of the metals industry. Under each classification appears the name of the exhibiting company followed by the booth number and a code letter referring to the floor plan of the general exhibit area (see leaf on far right). Thus, under Classification 1, Ferrous Metals, the exhibitor is listed as Allegheny Ludlum (114-A), indicating the display is located in Booth 114 in the arena (section A on the floor plan). An alphabetical listing of exhibitors appears on the inside of the gatefold.

1. **Ferrous Metals**
2. **Nonferrous Metals**
3. **Related Engineering Materials**
4. **Nuclear Materials and Equipment**
5. **Tool Materials, Cutting and Forming Equipment**
6. **Industrial Heating Equipment and Supplies**
7. **Cleaning and Finishing Equipment and Supplies**
8. **Welding and Joining Equipment and Supplies**
9. **Inspection and Control Equipment and Supplies**
10. **Production and Casting Equipment and Supplies**
11. **Parts, Forms, and Shapes for Design and Application**

1 Ferrous Metal Producers and Distributors

Allegheny-Ludlum Steel (114-A)
Babcock & Wilcox Co., Tubular Products Div. (312-A)
Bishop & Co., J. (1829-GH)
Braeburn Alloy Steel (203-A)
Brooklyn Steel Warehouse (1870-GH)
Canada, Dept. of Trade & Commerce (1510-GH)
Carpenter Steel Co. (222-A)
Cooper Metallurgical Assoc. (1864-GH)
Copperweld Steel Co. (138-A)
Crucible Steel Co. (346-A)
Firth Sterling Inc. (103-A)
General Alloys Co. (930-CE)
Great Lakes Steel (246-A)
International Nickel Co. (122-A)
Jones & Laughlin, Stainless and Strip Div. (335-A)
Latrobe Steel Co. (119-A)
National-Standard Co. (1377-GH)
National Steel Corp., Enamelstrip Div. (246-A)
Republic Steel Corp. (214-A)
Timken Roller Bearing Co., Timken Steel and Tube Div. (129-A)
Ulbrich Stainless Steels (109-A)
Universal-Cyclops Steel (305-A)
Vanadium Alloys Steel (320-A)
Vanadium Corp. of Amer. (204-A)
Washington Steel Corp. (146-A)
Westinghouse Electric (702-CO)

2 Nonferrous Metal Producers and Distributors

Al-Fin Corp. (1855-GH)
Aluminum Co. of Amer. (1410-GH)
Beryllium Corp. (1319-GH)
Bishop & Co., J. (1829-GH)
Brooklyn Steel Warehouse (1870-GH)
Brush Beryllium Co. (718-CO)
Canada, Dept. of Trade & Commerce (1510-GH)
Cobalt Information Center (1216-GH)
Cooper Metallurgical Assoc. (1864-GH)
Crucible Steel Co. (346-A)
Gries Reproducer Corp. (1211-GH)
Haynes-Stellite Co., Div. of Union Carbide Corp. (1032-CE)
International Nickel Co. (122-A)
Janney Cylinder Co. (1453-GH)
Kawecki Chemical Co. (1350-GH)
Kester Solder Co. (1954-GH)
National-Standard Co. (1377-GH)
Republic Steel Corp. (214-A)
Tin Research Institute (1210-GH)
Union Carbide Metals Co., Div. of Union Carbide Corp. (1032-CE)
Westinghouse Electric (702-CE)

3 Related Engineering Materials

Al-Fin Corp. (1855-GH)
Aluminum Co. of Amer. (1410-GH)
Amersil Quartz Div. (1839-GH)
ASM Automotive Exhibit (1310-GH)
Beemer Engineering (1929-GH)
Fuller Co., H. B. (1273-GH)
National Carbon Co., Div. of Union Carbide Corp. (1032-CE)
National-Standard Co. (1377-GH
Polymer Corp. (508-CO)
Steco Corp. (1342-GH)
Tempil Corp. (1327-GH)
Union Carbide Corp. (1032-CE)
Van der Horst Corp. (1868-GH)

4 Nuclear Materials and Equipment

Allegheny-Ludlum Steel (114-A)
Amer. Machine & Metals (1909-GH)
Arcweld Mfg. Co. (1818-GH)
Babcock & Wilcox Co., Tubular Products Div. (312-A)
Bishop & Co., J. (1829-GH)
Carpenter Steel Co. (222-A)
Cobalt Information Center (1216-GH)
Cooper Metallurgical Assoc. (1864-GH)
Crucible Steel Co. (346-A)
Harper Electric Furnace (1857-GH)
Instron Engrg. Corp. (808-CO)
International Nickel Co. (122-A)
National Carbon Co., Div. of Union Carbide Corp. (1032-CE)
Radionics, Inc. (1539-GH)
Tempil Corp. (1327-GH)
Universal-Cyclops Steel (305-A)
Van der Horst Corp. (1868-GH)

5 Tool Materials, Cutting and Forming Equipment

Allegheny-Ludlum Steel (114-A)
Allison-Campbell Div., American Chain & Cable Co. (1466-GH)
American Pullmax Co. (1756-GH)
Antares Instruments (1758-GH)
Balcrank Inc. (1266-GH)
Barer Engineering & Machinery Co., Ltd. (1868-GH)
Bliss Co., E. W. (1564-GH)
Braeburn Alloy Steel (203-A)
Canada, Dept. of Trade & Commerce (1510-GH)
Carpenter Steel Co. (222-A)
Cobalt Information Center (1216-GH)
Crucible Steel Co. (346-A)
Dayton Perforators (915-CE)
Disston Div., H. K. Porter (1950-GH)
Dixon Crucible Co., J. (1858-GH)
Firth Sterling Inc. (103-A)
Gulf Oil Corp. (1523-GH)
Heller's Son, E. G. (1760-GH)
Houghton & Co., E. F. (709-CO)
Latrobe Steel Co. (119-A)
Marquardt Corp. (1672-GH)
Matthews Co., J. H. (1027-GE)
Merrill Brothers (1372-GH)
Oliver Machinery Co. (1355-GH)
Portomag, Inc. (1963-GH)
Raytheon Co. (1277-GH)
Relton Corp. (1661-GH)
Shell Oil Co. (1550-GH)
Sieburg Industries (1869-
Texaco, Inc. (803-CO)
Universal-Cyclops Steel (
Vanadium-Alloys Steel (3
Wales Strippit Inc. (1658-
Wells Mfg. Co. (1339-GH)

Industrial Hea Equipment an

Aerobraze Corp. (1274-G
Ajax Electric Co. (717-CO
Ajax Magnethermic (1810
American Gas Assoc. (191
American Gas Furnace (1
Arcweld Mfg. Co. (1818-G
Audubon Metalwove Bel nese Steel Forge (617-C
Barber-Colman Co., Whe ments Div. (1921-GH)
Bliss Co., E. W. (1564-GH
Cincinnati Sub Zero (196
Consolidated Vacuum (12
Day Engineering, Inc. (17
Dixon Crucible Co. (1858-
Dry Clime Lamp Corp. (1
Electric Furnace Co. (134
Electric Hotpack Co. (125
Electrohome Technical Pr 1817-GH)
Engelhard Industries (183
Gas Appliance Service (15
General Alloys Co. (930-C
General Electric Co. (161
Gulf Oil Corp. (1523-GH)
Hacker & Co., William J.
Hamler Industries, Inc.
Harper Electric Furnace
Harris Mfg. Co., Inc. (13
Hayes, Inc., C. I. (1454-GH
Hevi-Duty Electric Co., C (501-CO)
High Vacuum Equipment
Holcroft & Co. (704-CO)
Hones, Inc., Chas. A. (1910
Houghton & Co., E. F. (70
Illinois Testing Labs. (145
Ionic Electrostatic Corp.
Ipsen Industries (1601-GH
Johnson Gas Appliance
Kinney Mfg. Div., New Yo Co. (1471-GH)
Laboratory Equipment C
Leeds & Northrup Co. (13
Lepel High Frequency La
Lindberg Engineering (62
Metlab Co. (1842-GH)
Minneapolis-Honeywell R (1458-GH)
NRC Equipment Corp. (12
Ohio Crankshaft Co., Too (1757-GH)
Park Chemical Co. (1850-
Perfection Industries, Div Corp. (1910-GH)
Philco Corp. (1549-GH)
Radio Frequency Co. (185
Rolock, Inc. (1809-GH)

(1550-GH)
ustries (1869-GH)
(803-CO)
yclops Steel (305-A)
Alloys Steel (320-A)
pit Inc. (1658-GH)
Co. (1339-GH)

ustrial Heating ipment and Supplies

Corp. (1274-GH)
ic Co. (717-CO)
thermic (1810-GH)
as Assoc. (1910-GH)
as Furnace (1910-GH)
g. Co. (1818-GH)
letalwove Belt Div., Manga-
l Forge (617-CO)
man Co., Wheelco Instru-
. (1921-GH)
. W. (1564-GH)
Sub Zero (1959-GH)
d Vacuum (1219-GH)
ering, Inc. (1710-GH)
ible Co. (1858-GH)
Lamp Corp. (1571-GH)
rnace Co. (1341-GH)
pack Co. (1250-GH)
e Technical Products Div.

Industries (1839-GH)
ice Service (1910-GH)
oys Co. (930-CE)
ectric Co. (1610-GH)
rp. (1523-GH)
o., William J. (1449-GH)
lustries, Inc. (1568-GH)
tric Furnace (1857-GH)
Co., Inc. (1326-GH)
C. I. (1454-GH)
Electric Co., Como Cast Div.

m Equipment (1417-GH)
Co. (704-CO)
Chas. A. (1910-GH)
Co., E. F. (709-CO)
ing Labs. (1457-GH)
rostatic Corp. (1972-GH)
tries (1601-GH)
s Appliance (1956-GH)
. Div., New York Air Brake
GH)
Equipment Corp. (1967-GH)
rthrup Co. (1315-GH)
Frequency Lab. (1228-GH)
ngineering (624-CO)
(1842-GH)
-Honeywell Regulator Co.
)
ment Corp. (1301-GH)
shaft Co., Tocco Div.
)
ical Co. (1850-GH)
ndustries, Div. of Hupp
0-GH)
. (1549-GH)
ency Co. (1851-GH)
(1809-GH)

Ross Engineering Div., Midland Ross Corp. (1540-GH)
Scientific Electric (1972-GH)
Selas Corp. of Amer. (1910-GH)
Shampaine Scientific Co. (1866-GH)
Spencer Turbine Co. (1910-GH)
Stokes Corp., F. J. (1625-GH)
Surface Combustion Div., Midland-Ross Corp. (1540-GH)
Tempil Corp. (1327-GH)
Texaco, Inc. (803-CO)
Waukee Engineering (1277-GH)
West Instrument Corp. (1461-GH)
Westinghouse Electric (702-CO)
Wiegand Co., Edwin L. (1363-GH)

Cleaning and Finishing Equipment and Supplies

Allison-Campbell Div., American Chain & Cable Co. (1466-GH)
Balcrank Inc. (1266-GH)
Binks Mfg. Co. (515-CO)
Blakeslee & Co., G. S. (1401-GH)
Branson Ultrasonic (1539-GH)
Circo Equipment Co. (1654-GH)
Columbus Coated Fabrics (926-CE)
Corrosion Reaction Consultants, Inc. (1933-GH)
Detrex Chemical Industries (1206-GH)
Dixon Crucible Co., J. (1858-GH)
Dow Chemical Co. (1519-GH)
duPont de Nemours & Co., E. I., (1405-GH)
Eclipse Air Brush Co. (1572-GH)
Engelhard Industries (1839-GH)
G. S. Equipment Co. (512-CO)
General American Trans. Corp., Kanigen Div. (1336-GH)
Gray Co., Inc. (1719-GH)
Harris Transducer Corp., Ultrasonic Div. (1620-GH)
Harshaw Chemical Co. (602-CO)
Houghton & Co., E. F. (709-CO)
Ionic Electrostatic (1972-GH)
Kawecki Chemical Co. (1350-GH)
Kolene Corp. (1251-GH)
Lake Chemical Co. (1450-GH)
Manpro Corp. (925-CE)
Metal Finishers, Inc. (1862-GH)
Minnesota Mining & Mfg. (1467-GH)
Moore & Co., Samuel (1750-GH)
National Ultrasonic Corp. (1969-GH)
Nordson Corp. (1309-GH)
Oakite Products (1420-GH)
Pangborn Corp. (931-CE)
Pennsalt Chemicals (1556-GH)
Philco Corp. (1549-GH)
Phillips Mfg. Co. (518-CO)
Powertron Ultrasonic (1867-GH)
Radio Frequency Co. (1851-GH)
Ransburg Electro Coating (1520-GH)
Service Hard Chromium (1362-GH)
Spee-Flo Co. (1854-GH)
Syntron Co. (1825-GH)
Turco Products (1728-GH)
U. S. Electrical Motors (1822-GH)
Van der Horst Corp. (1868-GH)
Vic Mfg. Co. (1717-GH)

Waldron-Hartig Div., Midland Ross Corp. (1540-GH)
Waukee Engineering Co. (1277-GH)
Westinghouse Electric (702-CO)
Weigand Co., Edwin L. (1363-GH)
Wyandotte Chemicals (1772-GH)

Welding and Joining Equipment and Supplies

Aerobraze Corp. (1274-GH)
Ajax Magnethermic (1810-GH)
American Gas Assoc. (1910-GH)
American Gas Furnace (1910-GH)
Banner Welder, Inc. (1701-GH)
Bren Weld Corp. (1267-GH)
Fuller Co., H. B. (1273-GH)
Guthery Machine Tool Corp., Aro Spot Welder Div. (1368-GH)
High Vacuum Equipment (1417-GH)
Hobart Bros. Co. (1636-GH)
KSM Products, Inc. (1716-GH)
Lepel High Frequency Lab. (1228-GH)
Lindberg Engineering (624-CO)
Materials Research (618-CO)
Parker-Kalon Div. (1338-GH)
Raytheon Corp. (1277-GH)
Relton Corp. (1861-GH)
Selas Corp. of Amer. (1910-GH)
Smith Corp., A. O. (1650-GH)
South Chester Corp., Southco Div. (623-CO)
Star Expansion Corp. (1354-GH)
Stimpson Co., E. B. (605-CO)
Westinghouse Electric (702-CO)

Inspection and Control Equipment and Supplies

American Cystoscope Makers (1669-GH)
American Optical Co., Instrument Div. (805-CO)
Amer. Machine & Metals (1909-GH)
Arcweld Mfg. Co. (1818-GH)
Balteau Electric Corp. (817-CO)
Barber-Colman Co., Wheelco Instruments Div. (1921-GH)
Bausch & Lomb Optical (1419-GH)
Budd Co. (1420-GH)
Buehler Ltd. (816-CO)
Collins Microflat Co. (1665-GH)
CompuDyne Corp. (1960-GH)
Cooke, Troughton & Simms (706-CO)
Curtiss-Wright Corp., Princeton Div. (1801-GH)
Daystrom Inc., Weston Instruments Div. (1577-GH)
Detroit Testing Machine (1946-GH)
Eastman Kodak Co. (1727-GH)
Edmund Scientific (1771-GH)
Elion Ultrasonics (1630-GH)
Engelhard Industries (1839-GH)
Gries Industries, Inc. (1215-GH)
Hacker & Co., W. J. (1449-GH)
Harshaw Scientific, Div. of Harshaw Chemical Co. (602-CO)
Hastings-Raydist, Inc. (1971-GH)
High Vacuum Equipment (1417-GH)
Howe Sound Co. (1657-GH)

Illinois Testing Labs. (1457-GH)
Instron Engineering Corp. (808-CO)
Instrument Development Lab. (1764-GH)
Ipsen Industries (1601-GH)
Jem Penetrameter Mfg. (1872-GH)
King Tester Corp. (619-CO)
Laboratory Equipment (1967-GH)
Leeds & Northrup Co. (1315-GH)
Leitz, Inc. (1278-GH)
Lindberg Engineering (624-CO)
Magnaflux Corp. (1619-GH)
Magnetic Analysis (1560-GH)
Mahr Gage Co., Inc. (610-CO)
Markal Co. (1450-GH)
Materials Research (618-CO)
Metalographic Exhibits (1937-GH)
Mine Safety Appliances (1767-GH)
Minneapolis-Honeywell (1458-GH)
Newage Industries, Inc. (1275-GH)
Olsen Testing Machine (1720-GH)
Philco Corp. (1549-GH)
Picker X-Ray Corp. (1561-GH)
Pyrometer Instrument (1742-GH)
Radiation Electronics Co., Div. of Comptometer Corp. (1553-GH)
Riehle Testing Machines Div., American Machine & Metals (1909-GH)
Scherr-Tumico Co. (1240-GH)
Shaw Instrument Corp. (1871-GH)
Special Libraries Asso. (1673-GH)
Sperry Products Co. (724-CO)
Steel City Testing Machines (1746-GH)
Stokes Corp., F. J. (1625-GH)
Syntron Co. (1825-GH)
Tempil Corp. (1327-GH)
Torsion Balance Co. (1533-GH)
Turco Products Inc. (1728-GH)
United Scientific Co., Unitron Instrument Div. (1439-GH)
West Instrument Corp. (1461-GH)
Westinghouse Electric (702-CO)
Wiedemann Machine Co. (1349-GH)
Wilson Mechanical Instrument Div., American Chain & Cable (1330-GH)
X-Ray Products Div., Oscar Fisher Co. (1634-GH)

Production and Casting Equipment and Supplies

Ajax Electric Co. (717-CO)
Ajax Magnethermic (1810-GH)
Aluminum Co. of Amer. (1410-GH)
American Gas Assoc. (1910-GH)
American Gas Furnace (1910-GH)
Antares Instruments (1758-GH)
Audubon Metalwove Belt Div., Manganese Steel Forge (617-CO)
Bliss Co., E. W. (1564-GH)
Consolidated Vacuum (1219-GH)
Dixon Crucible Co., J. (1858-GH)
Exomet, Inc. (1239-GH)
Hevi-Duty Electric (501-CO)
Hones, Inc., Charles A. (1910-GH)
International Nickel (122-A)
Martin Engineering Co. (1279-GH)
Materials Research (618-CO)
Merrill Brothers (1372-GH)

Shell Oil Co. (1550-GH)
Sieburg Industries (1869-GH)
Texaco, Inc. (803-CO)
Universal-Cyclops Steel (305-A)
Vanadium-Alloys Steel (320-A)
Wales Strippit Inc. (1658-GH)
Wells Mfg. Co. (1339-GH)

Industrial Heating Equipment and Supplies

Aerobraze Corp. (1274-GH)
Ajax Electric Co. (717-CO)
Ajax Magnethermic (1810-GH)
American Gas Assoc. (1910-GH)
American Gas Furnace (1910-GH)
Arcweld Mfg. Co. (1818-GH)
Audubon Metalwove Belt Div., Manganese Steel Forge (617-CO)
Barber-Colman Co., Wheelco Instruments Div. (1921-GH)
Bliss Co., E. W. (1564-GH)
Cincinnati Sub Zero (1959-GH)
Consolidated Vacuum (1219-GH)
Day Engineering, Inc. (1710-GH)
Dixon Crucible Co. (1858-GH)
Dry Clime Lamp Corp. (1571-GH)
Electric Furnace Co. (1341-GH)
Electric Hotpack Co. (1250-GH)
Electrohome Technical Products Div. 1817-GH)
Engelhard Industries (1839-GH)
Gas Appliance Service (1910-GH)
General Alloys Co. (930-CE)
General Electric Co. (1610-GH)
Gulf Oil Corp. (1523-GH)
Hacker & Co., William J. (1449-GH)
Hamler Industries, Inc. (1568-GH)
Harper Electric Furnace (1857-GH)
Harris Mfg. Co., Inc. (1326-GH)
Hayes, Inc., C. I. (1454-GH)
Hevi-Duty Electric Co., Como Cast Div. (501-CO)
High Vacuum Equipment (1417-GH)
Holcroft & Co. (704-CO)
Hones, Inc., Chas. A. (1910-GH)
Houghton & Co., E. F. (709-CO)
Illinois Testing Labs. (1457-GH)
Ionic Electrostatic Corp. (1972-GH)
Ipsen Industries (1601-GH)
Johnson Gas Appliance (1956-GH)
Kinney Mfg. Div., New York Air Brake Co. (1471-GH)
Laboratory Equipment Corp. (1967-GH)
Leeds & Northrup Co. (1315-GH)
Lepel High Frequency Lab. (1228-GH)
Lindberg Engineering (624-CO)
Metlab Co. (1842-GH)
Minneapolis-Honeywell Regulator Co. (1458-GH)
NRC Equipment Corp. (1301-GH)
Ohio Crankshaft Co., Tocco Div. (1757-GH)
Park Chemical Co. (1850-GH)
Perfection Industries, Div. of Hupp Corp. (1910-GH)
Philco Corp. (1549-GH)
Radio Frequency Co. (1851-GH)
Rolock, Inc. (1809-GH)
Ross Engineering Div., Midland Ross Corp. (1540-GH)
Scientific Electric (1972-GH)
Selas Corp. of Amer. (1910-GH)
Shampaine Scientific Co. (1866-GH)
Spencer Turbine Co. (1910-GH)
Stokes Corp., F. J. (1625-GH)
Surface Combustion Div., Midland-Ross Corp. (1540-GH)
Tempil Corp. (1327-GH)
Texaco, Inc. (803-CO)
Waukee Engineering (1277-GH)
West Instrument Corp. (1461-GH)
Westinghouse Electric (702-CO)
Wiegand Co., Edwin L. (1363-GH)

Cleaning and Finishing Equipment and Supplies

Allison-Campbell Div., American Chain & Cable Co. (1466-GH)
Balcrank Inc. (1266-GH)
Binks Mfg. Co. (515-CO)
Blakeslee & Co., G. S. (1401-GH)
Branson Ultrasonic (1539-GH)
Circo Equipment Co. (1654-GH)
Columbus Coated Fabrics (926-CE)
Corrosion Reaction Consultants, Inc. (1933-GH)
Detrex Chemical Industries (1205-GH)
Dixon Crucible Co., J. (1858-GH)
Dow Chemical Co. (1519-GH)
duPont de Nemours & Co., E. I., (1405-GH)
Eclipse Air Brush Co. (1572-GH)
Engelhard Industries (1839-GH)
G. S. Equipment Co. (512-CO)
General American Trans. Corp., Kanigen Div. (1336-GH)
Gray Co., Inc. (1719-GH)
Harris Transducer Corp., Ultrasonic Div. (1620-GH)
Harshaw Chemical Co. (602-CO)
Houghton & Co., E. F. (709-CO)
Ionic Electrostatic (1972-GH)
Kawecki Chemical Co. (1350-GH)
Kolene Corp. (1251-GH)
Lake Chemical Co. (1450-GH)
Manpro Corp. (925-CE)
Metal Finishers, Inc. (1862-GH)
Minnesota Mining & Mfg. (1467-GH)
Moore & Co., Samuel (1750-GH)
National Ultrasonic Corp. (1969-GH)
Nordson Corp. (1309-GH)
Oakite Products (1420-GH)
Pangborn Corp. (931-CE)
Pennsalt Chemicals (1556-GH)
Philco Corp. (1549-GH)
Phillips Mfg. Co. (518-CO)
Powertron Ultrasonic (1867-GH)
Radio Frequency Co. (1851-GH)
Ransburg Electro Coating (1520-GH)
Service Hard Chromium (1362-GH)
Spec-Flo Co. (1854-GH)
Syntron Co. (1825-GH)
Turco Products (1728-GH)
U. S. Electrical Motors (1822-GH)
Van der Horst Corp. (1868-GH)
Vic Mfg. Co. (1717-GH)
Waldron-Hartig Div., Midland Ross Corp. (1540-GH)
Waukee Engineering Co. (1277-GH)
Westinghouse Electric (702-CO)
Weigand Co., Edwin L. (1363-GH)
Wyandotte Chemicals (1772-GH)

Welding and Joining Equipment and Supplies

Aerobraze Corp. (1274-GH)
Ajax Magnethermic (1810-GH)
American Gas Assoc. (1910-GH)
American Gas Furnace (1910-GH)
Banner Welder, Inc. (1701-GH)
Bren Weld Corp. (1257-GH)
Fuller Co., H. B. (1273-GH)
Guthery Machine Tool Corp., Aro Spot Welder Div. (1368-GH)
High Vacuum Equipment (1417-GH)
Hobart Bros. Co. (1636-GH)
KSM Products, Inc. (1716-GH)
Lepel High Frequency Lab. (1228-GH)
Lindberg Engineering (624-CO)
Materials Research (618-CO)
Parker-Kalon Div. (1338-GH)
Raytheon Corp. (1277-GH)
Relton Corp. (1861-GH)
Selas Corp. of Amer. (1910-GH)
Smith Corp., A. O. (1650-GH)
South Chester Corp., Southco Div. (623-CO)
Star Expansion Corp. (1354-GH)
Stimpson Co., E. B. (805-CO)
Westinghouse Electric (702-CO)

Inspection and Control Equipment and Supplies

American Cystoscope Makers (1669-GH)
American Optical Co., Instrument Div. (805-CO)
Amer. Machine & Metals (1909-GH)
Arcweld Mfg. Co. (1818-GH)
Balteau Electric Corp. (817-CO)
Barber-Colman Co., Wheelco Instruments Div. (1921-GH)
Bausch & Lomb Optical (1419-GH)
Budd Co. (1420-GH)
Buehler Ltd. (816-CO)
Collins Microflat Co. (1665-GH)
CompuDyne Corp. (1960-GH)
Cooke, Troughton & Simms (706-CO)
Curtiss-Wright Corp., Princeton Div. (1801-GH)
Daystrom Inc., Weston Instruments Div. (1577-GH)
Detroit Testing Machine (1946-GH)
Eastman Kodak Co. (1727-GH)
Edmund Scientific (1771-GH)
Elion Ultrasonics (1630-GH)
Engelhard Industries (1839-GH)
Gries Industries, Inc. (1215-GH)
Hacker & Co., W. J. (1449-GH)
Harshaw Scientific, Div. of Harshaw Chemical Co. (602-CO)
Hastings-Raydist, Inc. (1971-GH)
High Vacuum Equipment (1417-GH)
Howe Sound Co. (1657-GH)

Illinois Testing Labs. (1457-GH)
Instron Engineering Corp. (808-CO)
Instrument Development Lab. (1764-GH)
Ipsen Industries (1601-GH)
Jem Penetrameter Mfg. (1872-GH)
King Tester Corp. (619-CO)
Laboratory Equipment (1967-GH)
Leeds & Northrup Co. (1315-GH)
Leitz, Inc. (1278-GH)
Lindberg Engineering (624-CO)
Magnaflux Corp. (1619-GH)
Magnetic Analysis (1560-GH)
Mahr Gage Co., Inc. (610-CO)
Markal Co. (1450-GH)
Materials Research (618-CO)
Metalographic Exhibits (1937-GH)
Mine Safety Appliances (1767-GH)
Minneapolis-Honeywell (1458-GH)
Newage Industries, Inc. (1275-GH)
Olsen Testing Machine (1720-GH)
Philco Corp. (1549-GH)
Picker X-Ray Corp. (1561-GH)
Pyrometer Instrument (1742-GH)
Radiation Electronics Co., Div. of Comptometer Corp. (1553-GH)
Riehle Testing Machines Div., American Machine & Metals (1909-GH)
Scherr-Tumico Co. (1240-GH)
Shaw Instrument Corp. (1871-GH)
Special Libraries Asso. (1673-GH)
Sperry Products Co. (724-CO)
Steel City Testing Machines (1746-GH)
Stokes Corp., F. J. (1625-GH)
Syntron Co. (1825-GH)
Tempil Corp. (1327-GH)
Torsion Balance Co. (1533-GH)
Turco Products Inc. (1728-GH)
United Scientific Co., Unitron Instrument Div. (1439-GH)
West Instrument Corp. (1461-GH)
Westinghouse Electric (702-CO)
Wiedemann Machine Co. (1349-GH)
Wilson Mechanical Instrument Div., American Chain & Cable (1330-GH)
X-Ray Products Div., Oscar Fisher Co. (1634-GH)

Production and Casting Equipment and Supplies

Ajax Electric Co. (717-CO)
Ajax Magnethermic (1810-GH)
Aluminum Co. of Amer. (1410-GH)
American Gas Assoc. (1910-GH)
American Gas Furnace (1910-GH)
Antares Instruments (1758-GH)
Audubon Metalwove Belt Div., Manganese Steel Forge (617-CO)
Bliss Co., E. W. (1564-GH)
Consolidated Vacuum (1219-GH)
Dixon Crucible Co., J. (1858-GH)
Exomet, Inc. (1239-GH)
Hevi-Duty Electric (501-CO)
Hones, Inc., Charles A. (1910-GH)
International Nickel (122-A)
Martin Engineering Co. (1279-GH)
Materials Research (618-CO)
Merrill Brothers (1272-GH)
National Carbon Co., Div. of Union Carbide Corp. (1032-CE)
Philco Corp. (1549-GH)
Spencer Turbine Co. (1910-GH)
Stokes Corp. F. J. (1625-GH)
Surface Combustion Div., Midland-Ross Corp. (1540-GH)
Tempil Corp. (1327-GH)
Union Carbide Corp. (1032-CE)
Union Carbide Metals Div., Union Carbide Corp. (1032-CE)
Vanadium Corp. of Amer. (204-A)
WalMet Alloys Co. (1657-GH)

Parts, Forms, Shapes for Design and Application

ACIPCO Special Products (1220-GH)
Al-Fin Div. (1855-GH)
Aluminum Co. of Amer. (1410-GH)
Allegheny-Ludlum Steel (114-A)
Allen Aircraft, Inc. (1334-GH)
Alloy Steel Casting Div., Fischer & Porter Co. (1470-GH)
American Brake Shoe Co., Electro-Alloys Div. (608-CO)
American Cast Iron Pipe (1220-GH)
ASM Automotive Exhibit (1310-GH)
Amplex Div., Chrysler Corp. (1929-GH)
Babcock & Wilcox Co., Tubular Products Div. (312-A)
Balcrank Inc. (1266-GH)
Beemer Engineering Co. (1929-GH)
Beryllium Corp. (1319-GH)
Bishop & Co., J. (1829-GH)
Braeburn Alloy Steel (203-A)
Brush Beryllium Co. (718-CO)
Carpenter Steel Co. (222-A)
Cobalt Information Center (1216-GH)
Cooper Metallurgical (1864-GH)
Crucible Steel Co. (346-A)
Dixon Crucible Co., J. (1858-GH)
Dodge Steel Co. (1740-GH)
Driver Co., Wilbur B. (1567-GH)
Enamelstrip Div., National Steel Corp. (246-A)
Engelhard Industries (1839-GH)
Engineered Precision Casting Co. (1269-GH)
General Alloys Co. (930-CE)
Gries Reproducer Corp. (1211-GH)
Hamilton Watch Co. (1267-GH)
Haynes-Stellite Co., Div. of Union Carbide Corp. (1032-CE)
Heli-Coil Corp. (1316-GH)
Howe Sound Co. (1657-GH)
Hitchiner Mfg. Co. (1768-GH)
International Nickel Co. (122-A)
Janney Cylinder Co. (1453-GH)
Latrobe Steel Co. (119-A)
Moore & Co., Samuel (1750-GH)
National Carbon Co., Div. of Union Carbide Corp. (1032-CE)
National Steel Corp. (246-A)
New Hermes Engraving Machine Corp. (1762-GH)
Philco Corp. (1549-GH)
Republic Steel Corp. (214-A)
Rolock, Inc. (1809-GH)
Smith Corp., A. O. (1650-GH)
Timken Roller Bearing Co., Steel & Tube Div. (129-A)
Universal-Cyclops Steel (305-A)
Vanadium-Alloys Steel (220-A)

Publications

American Metal Market (1262-GH)
Chilton Co. (1661-GH)
Fairchild Publications (1753-GH)
Industrial Heating (1819-GH)
Industrial Press (1953-GH)
Industrial Publishing (1358-GH)
Metal Progress—ASM (145-A)
Penton Publishing Co. (1830-GH)
Reinhold Publishing Corp. (1256-GH)
Small Business Adm. (524-CO)
Social Security Adm. (1316-GH)
Thomas Publishing Co. (1964-GH)

Technical Programs of ASM and Cooperating Societies

Sessions of interest to everyone will be presented by the American Society for Metals; American Institute of Mining, Metallurgical, and Petroleum Engineers; Society for Nondestructive Testing; Industrial Heating Equipment Association; Metal Powder Industries Federation; Metal Treating Institute; Ultrasonic Manufacturers Association; and Special Libraries Association.

ASM Seminar—Strengthening Mechanisms in Solids

Oct. 15, 16, Bellevue-Stratford

Sat. 9:00 a.m.

Review of Strengthening Mechanisms . . . W. R. Hibbard, General Electric
Solid Solution . . . P. A. Flinn, Westinghouse
Work Hardening . . . L. Washburn, University of California

Sat. 2:00 p.m.

Direct Observation by Electron Transmission Microscopy . . . J. Nutting, Univ. of Cambridge
Radiation Hardening . . . G. H. Vineyard, Brookhaven
Point Defect Hardening . . . D. K. Wilsdorf, R. Maddin, D. G. F. Wilsdorf, U. of Pennsylvania

Sun. 9:00 a.m.

Martensitic Transformations . . . V. F. Zackay, Ford Motor
Precipitation Reactions . . . W. D. Robertson, Yale
Fine Particle Strengthening . . . R. W. Guard, General Electric Co.

Sun. 2:00 p.m.

Shock Waves . . . G. E. Dieter, DuPont
Ionic and Inorganic Solids . . . T. L. Johnston, C. Li, R. Stokes, Honeywell
Surface Effects . . . E. Machlin, Columbia University

ASM Technical Program

Oct. 17-21, Bellevue-Stratford

Mon. 9:00 a.m.
Physical Metallurgy—I

Constitution and Properties of Ti-Co Alloys . . . F. W. Yakymyshyn, G. R. Purdy, J. Gordon Parr, U. of Alberta; R. Taggart, U. of Washington
Self-Diffusion in Ni Single Crystals . . . A. Messner, R. Benson, J. E. Dorn, Univ. of California
Solubility of Oxygen in Delta Iron . . . E. S. Tankins, N. A. Gocken, Univ. of Pennsylvania
Diffusion of Carbon in Thorium . . . D. T. Paterson, Iowa State U.
Yield Point Phenomena in Ni-Ag Alloys . . . V. A. Phillips, R. B. Jones, General Electric Co.

Mon. 2:00 p.m.
Physical Metallurgy—II

Grey and White Solidification of

Tues. 2:00 p.m. Steel—II

Microstructure vs. Fatigue Strength and Structure . . . P. Shahinian, M. R. Achter, U. S. Navy; W. A. Pennington, U. of Maryland
Effect of P on Strength and Weldability of Austenitic Stainless . . . G. R. Rundell, Crucible; R. J. Raudebaugh, International Nickel
Size, Mn Content, and Curie Point of Carbides From Mn Steel . . . R. W. Gurry, Union Steel; J. Christakos, Esso Research; L. S. Darken, U. S. Steel

Tues. 2:00 p.m. Plastic Deformation

Yield Point in Cu and Ni Alloys . . . R. B. Jones, V. A. Phillips, G.E.
Dynamic Stress-Strain and Plastic Wave Propagation . . . R. Papirno, G. Gerard, New York U.
Precipitation of P From Alpha Fe; Its Effect on Deformation . . . E. Hornbogen, U. S. Steel
Activation Energies for Slip in Mg Single Crystals . . . T. A. Trozera, J. Mote, J. E. Dorn, U. of Calif.
Cylindrical Textures in W . . . S. Leber, General Electric Co.

Wed. 2:00 p.m. Steel—III

Corrosion of Stabilized Stainless Welds . . . C. L. Angerman, P. Kranzlein, DuPont
Metal Wear by Scoring . . . J. H. Olson, R. D. Chapman, Chrysler
Intergranular Oxidation of 18-8 Stainless . . . M. G. Fontana, F. H. Beck, H. W. Pickering, Ohio State
B in Steel . . . R. A. Grange, J. B. Mitchell, U. S. Steel
Determining Steel Hardness From Breadth of Diffraction Lines . . . R. E. Marburger, D. P. Koistinen, General Motors Co.

Wed. 2:00 p.m.
High Temperature Materials

Constitution of Re-Cb Alloys . . . P. Levesque, W. R. Bekebrede, H. A. Brown, Raytheon
Beta Transformation of Ti Alloys . . . E. L. Harmon, Electro Metallurgical; A. R. Troiano, Case Tech
Properties of Ta Alloys . . . F. P. Schmidt, F. C. Holden, H. R. Ogden, R. I. Jaffee, Battelle
Ni Alloys for High Temperature . . . J. C. Freche, W. J. Waters, T. J. Riley, N.A.S.A.
Martensitic Steels for High Temperature . . . A. Kasak, V. K. Chandhok, E. J. Dulis, Crucible
Oxidation of Ta . . . W. D. Klopp, D. J. Maykuth, R. I. Jaffee, Battelle Memorial Institute

Thurs. 9:00 a.m. Nuclear Materials

Solubility of U in Bi; Liquidus Curves for U-Zr-Bi System . . . G. D. Schweitzer, J. R. Weeks, Brookhaven
Alloying to Improve Ductility of Va

ASM Metals Engineering Program

Oct. 17-20, Bellevue-Stratford

Mon. 9:00 a.m.
Materials for Aerospace Age

Properties of Materials for Space . . . E. Scala, Avco
Fabrication Techniques . . . W. H. Grierson, U. S. Air Force
Selection of Materials . . . H. B. Probst, N.A.S.A.

Mon. 2:00 p.m. Metal Joining

Metallurgy of Weld Zone in Hy-80 Steel . . . G. N. Emmanuel, D. E. Young, G. L. Spahr, Babcock & Wilcox
Welding High-Tensile Steels for Heavy Equipment . . . R. Myer, Harnishfeger
Exothermic Brazing . . . R. A. Long, Narmco Industries

Tues. 9:00 a.m. Failure Analysis—I

Failure of Steam-Water Heat Exchangers . . . B. F. Brown, U. S. Navy
Material Failure In Service . . . J. B. Barriage, F.A.A.
High-Temperature Failures . . . R. Poley, Babcock & Wilcox

Tues. 2:00 p.m. Failure Analysis—II

Evaluation of Corrosion Performance . . . R. J. Landrun, DuPont
Evaluation of Aircraft Material By Fracture . . . W. E. Anderson, Boeing; P. C. Paris, U. of Wash.
Engineering Approach to Service Performance . . . C. Lipson, University of Michigan

Wed. 2:00 p.m.
Metallurgical Microscopy

Electron Microscope in Metallurgical Problems . . . J. Nutting, Cambridge Univ.
Quantitative Metallography . . . E. E. Underwood, Battelle
Microscopic Methods . . . J. W. Spretnak, Ohio State Univ.

Thurs. 9:00 a.m.
Structure vs. Properties—I

Notch Toughness of Unhardened Steel . . . R. D. Stout, E. H. Kottcamp, Lehigh
Fracture Toughness of Steel for Pressure Vessels . . . H. Bernstein, G. C. Young, U. S. Navy
Heat Treat Variables vs. Fracture of Steels . . . P. P. Pusak, U. S. Navy
Strengthening Steels by Deforming Austenite . . . R. A. Grange, J. B. Mitchell, U. S. Steel
Microstructure vs. Corrosion Resistance . . . A. M. Hall, W. K. Boyd, Battelle Memorial Inst.

ASM Symposium fo… Steel Users

Oct. 1…-20, Convention

Tues. 2… p.m. Stainless Ste…

Stainless Steel . . .
What …ord, Babcock & Wil…
Ruth… *Expect of Stainles…*
What …atticks, Crucible
K. A… *Stainless Steels* . . .
Special… Allegheny Ludlum
Lena…

Panel … Stainless Fabricatio…

Joining . . . G. E. Linnert, Ar…
Machin… . . . P. Ewing, Lat…
Formin… . . . W. L. Keene, S…
Steel…
Heat T… …ating . . . B. T. La…
Carp… …er Steel
Finish… . . . S. P. Odar, Rep…
Modera… . . . R. B. Gunn…
Steel…

Wed. 2… p.m. Tool Steels

Machi… …g Space Age Metal…
M. C… …etzger, L. A. Hause…
versa… Cyclops
Air-Ha… …ning Toolsteels . . .
Culp… …arpenter Steel
Distort… …and Cracking in…
Trea… …g . . . R. Harvey, Br…
Alloy… …eel

Thurs. …0 p.m.
Joining… …igh-Strength Steels

Hot Cr… …cing in 4340 Steel . . .
Mon… Battelle
T-1 St… . . . L. Keay, Lukens…
Low-A… …, High-Strength Ste…
C. A… …berger, Great Lakes…

AIM… Technical Prog… …m

Oct. …7-21, Sheraton Ho…

Mon. 9 … a.m. Thermodynam…
Phase … …ilibria and Structure
(Abstr… …Session)

Mon. 9 … a.m.
Stainle… Steel Metallurgy—I

17-7PH… …tainless . . . A. E. A…
G. K… …Manning, E. E. Under…
Batt… …ation of Semi-Aust…
Transf… . . . G. N. Aggen, …
Stain… …llegheny Ludlum
Lula… …in Austenitic and…
Carbid… . . . R. J. Bendure, …
Stat… …y, J. H. Waxweller, …
Iken… …copic Structure in…
Submi… …10 . . . J. J. Hauser, …
perir… …, B. R. Banerjee, Cr…
Cap… …ture . . . F. Garofal…
Creep-… …tmore, W. F. Domi…
W. …gen, U.S. Steel
Gem…

Mon. … a.m. Metallurgy i…
Army… …equirements, Applica…
and R… …rch

Comba… …nd Tactical Vehicles
C. B… …lter, U. S. Army
Comm… …ations . . . S. B. L…
U.S. …y
Solid … …ellant Rocket Motors
J. L. … Daniel, U.S. Army

Mon. 9 … a.m.
Ingot S… …cture Control—I

Ingot … …cture Control . . . W…
Tille… …Westinghouse
Solidif… …on in Undercooled M…
. . . … Walker, General Ele…
Segreg… …n Alloy Ingots . . .
Holl… …, Battelle

Mon. … a.m. Diffusion—I
… Magnetic Materials

Diffusi… …chenall, U. of Dela…

Point Defects in Pure Ni . . . J. J. Antal, A. Goland, Ordnance Materials Research
Transition Elements in Fe . . . E. P. Abrahamson, Watertown Arsenal
High-Temperature Piston Assembly . . . A. A. Giardini, J. E. Tydings, U.S. Army

Tues. 9:00 a.m.
Titanium (Abstract Session)

Tues. 9:00 a.m. Phase Transformation (Abstract Session)

Tues. 9:00 a.m. Process Simulation
Predicting Blast Furnace Operation With Computer . . . A. L. Hodge, Linde
Simultaneous Equation Models . . . D. C. McCune, J. & L.
Computer Simulation of Melt Shop Operation . . . A. Neate, W. J. Dacey, Steel Co. of Wales, Ltd.
Pyrometallurgical Research . . . R. J. Leary, Bur. Mines

Tues. 9:00 a.m.
Extremely High Pressures—I
Static Pressure Research in Metallurgy . . . J. E. Hilliard, Gen. Elec.
Phase Transitions of Pure Metals . . . G. C. Kennedy, U. of Calif.
Shock Waves . . . G. R. Cowan, DuPont

Tues. 2:00 p.m. Ti vs. Steel and Al in Pressure Vessels
Evaluation of Fracture Toughness . . . W. S. Pellini, J. E. Srawley, U. S. Navy
Pressure Vessels for Space . . . V. W. Cooke, R. C. Powell, Pratt and Whitney
Ductility in Aerospace Pressure Vessels . . . G. Gerard, N.Y.U.
Pressure Vessels for Hydrospace . . . G. Sorkin, U.S. Navy
Film: *"March of Titanium"* (Titanium Metals Corp.)

Tues. 2:00 p.m. Panel Discussion on Hot Extrusion
Introduction . . . P. Loewenstein, A. Geary, Nuclear Metals, Inc.
Lead . . . F. A. C. Shaw, ASARCO
Aluminum . . . M. E. Molitor, Kaiser
Magnesium . . . (to be announced)
Copper . . . T. S. Howald, Chase Brass
Nuclear Materials . . . A. White, Nuclear Metals, Inc.
Summary . . . P. Loewenstein, Nuclear Metals, Inc.

Tues. 2:00 p.m. Physical Chemistry
McWane Process . . . T. Ban, McDowell; B. Worthington, McWane
Kinetics of Iron Oxide Reduction . . . A. Wilhelem, G. St. Pierre, Ohio State
Sulphide Inclusions . . . L. van Vlack, D. K. Riegger, R. J. Warrick, J. M. Dahl, U. of Michigan
Phase Equilibrium of Nonmetallics in FeO-MnO-MnS-SiO$_2$ System . . . E. H. Silverman, U.S. Steel
Cr vs. S Activity in Liquid Fe . . . N. R. Griffing, G. W. Healy, Union Carbide

Tues. 2:00 p.m. Extremely High Pressures—II (Abstract Session)

Wed. 9:00 a.m. Diffusion Controlled Processes (Abstract Session)

Wed. 9:00 a.m. Metallic Moderators and Cladding Materials—I
Zircaloy Tubing for Cladding Nuclear Fuel . . . R. C. Aungst, K. M. Haws, P. L. Farnsworth, G.E.
Zircaloy-2 Tubing . . . H. H. Klepfer, C. N. Spalaris, General Electric
Zircaloy-4 . . . J. N. Chirigos, S. Kass, W. W. Kirk, G. J. Salvaggio,

Zirconium Hydride and CO_2 . . . H. E. Shoemaker, General Atomic
Cladding of Zirconium Hydride . . . E. S. Hodge, S. J. Paprocki, Battelle

Wed. 2:00 p.m. Structural Materials in Cryogenic Design
Design Criteria for Tanks . . . R. E. Jacobsen, Boeing
Design Criteria for Airborne Tanks . . . R. Markovich, Martin
Cryogenic Structural Materials . . . E. W. Johnson, Alcoa
Aerospace Materials . . . J. Watson, Convair
Temperature vs. Fracture Testing of High-Strength Sheet . . . J. E. Srawley, U.S. Naval Research
Notch-Sensitivity of High-Strength Sheet . . . W. F. Brown, N.A.S.A.

Wed. 2:00 p.m. Symposium: Austenite Decomposition—II
Elementary Reactions in Decomposition . . . R. I. Entin, Central Research Inst., Moscow
Thermodynamics of Bainite Reaction . . . L. Kaufman, Manufacturing Labs.; S. V. Radcliffe, M. Cohen, M.I.T.
Proeutectoid Ferrite and Cementite; Bainite Reaction . . . H. I. Aaronson, Ford
Growth Kinetics of Bainite Reaction . . . G. R. Speich, U.S. Steel
Surface Relief In Bainite Formation . . . J. W. Christian, Oxford
Transformation in Nonferrous Systems . . . C. W. Spencer, Cornell; D. J. Mack, U. of Wis.

Wed. 2:00 p.m. Plastic Deformation—I (Abstract Session)

Thurs. 9:00 a.m. Refractory Metals—Europe
Research . . . R. I. Jaffee, Battelle
Sheffield Refractory Metals Meeting . . . B. S. Lement, Manufacturing Labs.
AGARD Activities . . . N. E. Promisel, W. J. Harris, U.S. Navy

Thurs. 9:00 a.m. Plastic Deformation—II (Abstract Session)

Thurs. 9:00 a.m.—Powder Metallurgy—I (Abstract Session)

Thurs. 9:00 a.m. Engineering Fundamentals of Rolling Process
Present Status of Theory . . . L. F. Coffin, General Electric
Boundary Conditions at Roll-Material Interface . . . G. W. Pearsall, M. I. T.
Resulting Structure and Properties . . . W. R. Hibbard, G.E.

Thurs. 9:00 a.m. Precipitation and Dispersed Phases (Abstract Session)

Thurs. 2:00 p.m. Refractory Metals (Abstract Session)

Thurs. 2:00 p.m. Creep, Fatigue, and Fracture (Abstract Session)

Thurs. 2:00 p.m. Powder Metallurgy—II (Abstract Session)

Thurs. 2:00 p.m. Textures, Recrystallization and Recovery (Abstract Session)

SNT Technical Program

Oct. 17-21, Benjamin Franklin

Wed. 2:00 p.m. Applications of Testing in Electronics
Infrared Applications . . . J. H. Beardsley, Perkin-Elmer Corp.
Component Manufacturing . . . A. J. Heltner, Sylvania
Sub-System and System Levels . . . P. S. Dick, General Electric

Wed. 2:00 p.m.
Gas Transmission Plants and Piping (Three papers . . . to be announced)
Thurs. 9:00 a.m. General Testing
Photostress . . . P. Zandman, Budd Instruments Div.
Automatic Magnetic Particle Inspection . . . H. E. Farmer, G.E.
Experimental Stress Analysis . . . J. G. Locklin, F. C. Fleck, G.M.
Density-Ratio Method—Radiographs . . . R. J. Mascis, Aerojet-General

Thurs. 2:00 p.m.
Quality Assurance in the Field
Neutron Activation Analysis . . . S. Regas, Radiation Counter Lab.
Hardened Concrete . . . C. M. Shilstone, Shilstone Testing Labs.
Moisture and Density Measurement in Soils . . . J. E. Templeman, Nuclear-Chicago Corp.
Blacklight Inspection . . . R. K. Cornell, Black Light Products

Fri. 9:00 a.m. Educational Clinic
Scope . . . D. W. Ballard, Sandia
Radiography . . . W. D. Kiehle, Eastman Kodak
Fluoroscopy . . . W. R. Hampe, Westinghouse
Magnetic Particle Inspection . . . R. G. Strother, Magnaflux

Fri. 2:00 p.m. Educational Clinic
Penetrant Inspection . . . H. Migel, Magnaflux
Eddy Current . . . R. Hochschild, Budd
Ultrasonic Theory . . . H. Smolen, Frankford Arsenal
Ultrasonic Applications . . . W. C. Hitt, Automation Instruments

Industrial Heating Equipment Association

Oct. 18, Bellevue-Stratford

Tues. 9:00 a.m. Symposium: Heat Treating Stainless Steels
Atmospheres and Furnaces . . . B. A. Ruediger, General Electric
Brazing . . . H. M. Webber, Harper Electric Furnace Co.
Vacuum Furnaces . . . H. Westeren, C. I. Hayes
Flat Products . . . M. R. Ogle, Drever
Tube and Wire . . . C. H. Vaughn, Electric Furnace Co.

Metal Powder Industries Federation Symposium

Oct. 19, Bellevue-Stratford

Wed. 2:00 p.m. Powder Metallurgy
Sintered Brass . . . V. Tarr, Midwest Sintered Products Corp.
Ceramic Molds . . . A. Mason, D. Forbes, Hamilton Porcelains
Thin-Walled Cones . . . R. Powell, L. Zalesk, Frankford Arsenal
Iron Powder by Fluidized Bed Method . . . A. B. Backensto, Alan Wood Steel

Metal Treating Institute

Oct. 20, Bellevue-Stratford

Thurs. 9:00 a.m. Panel: Heat Treating Components for Space-Age Products
Vacuum Heat Treating . . . R. Krosh

Physical Metallurgy—II

Grey and White Solidification of

Alloying to Improve Ductility of Va

ance . . . A. M. Hall, W. K. Boyd, Battelle Memorial Inst.

Mon. 2 p.m. Diffusion—I

in Magnetic Material

Diffusi[illegible]chenall, U. of Del

ymposium for Users

-20, Convention Hall

p.m. Stainless Steels

Stainless Steel . . . J. B. ord, Babcock & Wilcox

Expect of Stainless . . . Mattlicks, Crucible

tainless Steels . . . A. J. llegheny Ludlum

Stainless Fabrication

. . G. E. Linnert, Armco

. . . P. Ewing, Latrobe

. . . W. L. Keene, Superior

uting . . . B. T. Lanphier, ter Steel

. . . S. P. Odar, Republic

. . . R. B. Gunia, U.S.

p.m. Tool Steels

Space Age Metals . . . ietzger, L. A. Hauser, Uni-Cyclops

ening Toolsteels . . . N. J. arpenter Steel

and Cracking in Heat . . . R. Harvey, Braeburn eel

0 p.m.

igh-Strength Steels

ing in 4340 Steel . . . R. E. Battelle

. . . L. Keay, Lukens Steel

High-Strength Steels . . . nberger, Great Lakes Steel

Technical um

7-21, Sheraton Hotel

a.m. Thermodynamics, ilibria and Structure Session)

a.m.

Steel Metallurgy—I

tainless . . . A. E. Austin, Manning, E. E. Underwood,

ation of Semi-Austenitic . . . G. N. Aggen, R. A. llegheny Ludlum

in Austenitic and PH . . . R. J. Bendure, L. C. y, J. H. Waxweller, Armco

copic Structure in Tem-10 . . . J. J. Hauser, J. M. B. R. Banerjee, Crucible

ture . . . F. Garofalo, R. tmore, W. P. Domis, F. gen, U.S. Steel

a.m. Metallurgy in the equirements, Applications, rch

nd Tactical Vehicles . . . lter, U. S. Army

ations . . . S. B. Levin, ny

ellant Rocket Motors . . . Daniel, U.S. Army

a.m.

cture Control—I

ucture Control . . . W. A. Westinghouse

ion in Undercooled Metals . Walker, General Electric

n in Alloy Ingots . . . J. W. y, Battelle

a.m. Diffusion—I

in Magnetic Materials . . .

Point Defects in Pure Ni . . . J. J. Antal, A. Goland, Ordnance Materials Research

Transition Elements in Fe . . . E. P. Abrahamson, Watertown Arsenal

High-Temperature Piston Assembly . . . A. A. Giardini, J. E. Tydings, U.S. Army

Tues. 9:00 a.m. Titanium (Abstract Session)

Tues. 9:00 a.m. Phase Transformation (Abstract Session)

Tues. 9:00 a.m. Process Simulation

Predicting Blast Furnace Operation With Computer . . . A. L. Hodge, Linde

Simultaneous Equation Models . . . D. C. McCune, J. & L.

Computer Simulation of Melt Shop Operation . . . A. Neate, W. J. Dacey, Steel Co. of Wales, Ltd.

Pyrometallurgical Research . . . R. J. Leary, Bur. Mines

Tues. 9:00 a.m. Extremely High Pressures—I

Static Pressure Research in Metallurgy . . . J. E. Hilliard, Gen. Elec.

Phase Transitions of Pure Metals . . . G. C. Kennedy, U. of Calif.

Shock Waves . . . G. R. Cowan, DuPont

Tues. 2:00 p.m. Ti vs. Steel and Al in Pressure Vessels

Evaluation of Fracture Toughness . . . W. S. Pellini, J. E. Srawley, U. S. Navy

Pressure Vessels for Space . . . V. W. Cooke, R. C. Powell, Pratt and Whitney

Ductility in Aerospace Pressure Vessels . . . G. Gerard, N.Y.U.

Pressure Vessels for Hydrospace . . . G. Sorkin, U.S. Navy

Film: *"March of Titanium"* (Titanium Metals Corp.)

Tues. 2:00 p.m. Panel Discussion on Hot Extrusion

Introduction . . . P. Loewenstein, A. Geary, Nuclear Metals, Inc.

Lead . . . F. A. C. Shaw, ASARCO

Aluminum . . . M. E. Molitor, Kaiser

Magnesium . . . (to be announced)

Copper . . . T. S. Howald, Chase Brass

Nuclear Materials . . . A. White, Nuclear Metals, Inc.

Summary . . . P. Loewenstein, Nuclear Metals, Inc.

Tues. 2:00 p.m. Physical Chemistry

McWane Process . . . T. Ban, McDowell; B. Worthington, McWane

Kinetics of Iron Oxide Reduction . . . A. Wilhelem, G. St. Pierre, Ohio State

Sulphide Inclusions . . . L. van Vlack, D. K. Riegger, R. J. Warrick, J. M. Dahl, U. of Michigan

Phase Equilibrium of Nonmetallics in FeO-MnO-MnS-SiO$_2$ System . . . E. H. Silverman, U.S. Steel

Cr vs. S Activity in Liquid Fe . . . N. R. Griffing, G. W. Healy, Union Carbide

Tues. 2:00 p.m. Extremely High Pressures—II (Abstract Session)

Wed. 9:00 a.m. Diffusion Controlled Processes (Abstract Session)

Wed. 9:00 a.m. Metallic Moderators and Cladding Materials—I

Zircaloy Tubing for Cladding Nuclear Fuel . . . R. C. Aungst, K. M. Haws, P. L. Farnsworth, G.E.

Zircaloy-2 Tubing . . . H. H. Klepfer, C. N. Spalaris, General Electric

Zircaloy-4 . . . J. N. Chirigos, S. Kass, W. W. Kirk, G. J. Salvaggio, Westinghouse

Zirconium Hydride and CO$_2$ . . . H. E. Shoemaker, General Atomic

Cladding of Zirconium Hydride . . . E. S. Hodge, S. J. Paprocki, Battelle

Wed. 2:00 p.m. Structural Materials in Cryogenic Design

Design Criteria for Tanks . . . R. E. Jacobsen, Boeing

Design Criteria for Airborne Tanks . . . R. Markovich, Martin

Cryogenic Structural Materials . . . E. W. Johnson, Alcoa

Aerospace Materials . . . J. Watson, Convair

Temperature vs. Fracture Testing of High-Strength Sheet . . . J. E. Srawley, U.S. Naval Research

Notch-Sensitivity of High-Strength Sheet . . . W. P. Brown, N.A.S.A.

Wed. 2:00 p.m. Symposium: Austenite Decomposition—II

Elementary Reactions in Decomposition . . . R. I. Entin, Central Research Inst., Moscow

Thermodynamics of Bainite Reaction . . . L. Kaufman, Manufacturing Labs.; S. V. Radcliffe, M. Cohen, M.I.T.

Proeutectoid Ferrite and Cementite; Bainite Reaction . . . H. I. Aaronson, Ford

Growth Kinetics of Bainite Reaction . . . G. R. Speich, U.S. Steel

Surface Relief In Bainite Formation . . . J. W. Christian, Oxford

Transformation in Nonferrous Systems . . . C. W. Spencer, Cornell; D. J. Mack, U. of Wis.

Wed. 2:00 p.m. Plastic Deformation—I (Abstract Session)

Thurs. 9:00 a.m. Refractory Metals—Europe

Research . . . R. I. Jaffee, Battelle

Sheffield Refractory Metals Meeting . . . B. S. Lement, Manufacturing Labs.

AGARD Activities . . . N. E. Promisel, W. J. Harris, U.S. Navy

Thurs. 9:00 a.m. Plastic Deformation—II (Abstract Session)

Thurs. 9:00 a.m.—Powder Metallurgy—I (Abstract Session)

Thurs. 9:00 a.m. Engineering Fundamentals of Rolling Process

Present Status of Theory . . . L. P. Coffin, General Electric

Boundary Conditions at Roll-Material Interface . . . G. W. Pearsall, M. I. T.

Resulting Structure and Properties . . . W. R. Hibbard, G.E.

Thurs. 9:00 a.m. Precipitation and Dispersed Phases (Abstract Session)

Thurs. 2:00 p.m. Refractory Metals (Abstract Session)

Thurs. 2:00 p.m. Creep, Fatigue, and Fracture (Abstract Session)

Thurs. 2:00 p.m. Powder Metallurgy—II (Abstract Session)

Thurs. 2:00 p.m. Textures, Recrystallization and Recovery (Abstract Session)

SNT Technical Program

Oct. 17-21, Benjamin Franklin

Mon. 9:00 a.m. Inspection of Steel

Wed. 2:00 p.m. Applications of Testing in Electronics

Infrared Applications . . . J. H. Beardsley, Perkin-Elmer Corp.

Component Manufacturing . . . A. J. Heitner, Sylvania

Sub-System and System Levels . . . P. S. Dick, General Electric

Wed. 2:00 p.m. Gas Transmission Plants and Piping (Three papers . . . to be announced)

Thurs. 9:00 a.m. General Testing

Photostress . . . F. Zandman, Budd Instruments Div.

Automatic Magnetic Particle Inspection . . . H. E. Farmer, G.E.

Experimental Stress Analysis . . . J. G. Locklin, F. C. Fleck, G.M.

Density-Ratio Method—Radiographs . . . R. J. Mascis, Aerojet-General

Thurs. 2:00 p.m. Quality Assurance in the Field

Neutron Activation Analysis . . . S. Regas, Radiation Counter Lab.

Hardened Concrete . . . C. M. Shilstone, Shilstone Testing Labs.

Moisture and Density Measurement in Soils . . . J. E. Templeman, Nuclear-Chicago Corp.

Blacklight Inspection . . . R. K. Cornell, Black Light Products

Fri. 9:00 a.m. Educational Clinic

Scope . . . D. W. Ballard, Sandia

Radiography . . . W. D. Kiehle, Eastman Kodak

Fluoroscopy . . . W. R. Hampe, Westinghouse

Magnetic Particle Inspection . . . R. G. Strother, Magnaflux

Fri. 2:00 p.m. Educational Clinic

Penetrant Inspection . . . H. Migel, Magnaflux

Eddy Current . . . R. Hochschild, Budd

Ultrasonic Theory . . . H. Smolen, Frankford Arsenal

Ultrasonic Applications . . . W. C. Hitt, Automation Instruments

Industrial Heating Equipment Association

Oct. 18, Bellevue-Stratford

Tues. 9:00 a.m. Symposium: Heat Treating Stainless Steels

Atmospheres and Furnaces . . . B. A. Ruediger, General Electric

Brazing . . . H. M. Webber, Harper Electric Furnace Co.

Vacuum Furnaces . . . H. Westeren, C. I. Hayes

Flat Products . . . M. R. Ogle, Drever

Tube and Wire . . . C. H. Vaughn, Electric Furnace Co.

Metal Powder Industries Federation Symposium

Oct. 19, Bellevue-Stratford

Wed. 2:00 p.m. Powder Metallurgy

Sintered Brass . . . V. Tarr, Midwest Sintered Products Corp.

Ceramic Molds . . . A. Mason, D. Forbes, Hamilton Porcelains

Thin-Walled Cones . . . R. Powell, L. Zalesk, Frankford Arsenal

Iron Powder by Fluidized Bed Method . . . A. B. Backensto, Alan Wood Steel

Metal Treating Institute

Oct. 20, Bellevue-Stratford

Thurs. 9:00 a.m. Panel: Heat Treating Components for Space-Age Products

Vacuum Heat Treating . . . R. Krogh, Ipsen Laboratories

Heat Treating Specifications . . .

Alphabetical Listing of Exhibitors

ACIPCO Special Products
Aerobrase Corp.
Ajax Electric Co.
Ajax Magnethermic Corp.
Al-Fin Div.
Allegheny-Ludlum Steel Corp.
Allen-Aircraft Products, Inc.
Allison-Campbell Div., American Chain and Cable
Alloy Steel Castings Div., Fischer & Porter
Aluminum Co. of America
American Brake Shoe Co., Electro Alloys Div.
American Cast Iron Pipe Co.
Frasse & Co., Inc., Peter A.
American Cystoscope Makers, Inc.
American Gas Association
American Gas Furnace Co.
American Machine & Metals, Inc.
American Metal Market
American Optical Co., Instrument Div.
American Pullmax Co., Inc.
American Society for Metals
Amersil Quartz Div., Engelhard Industries Inc.
Amplex Div., Chrysler Corp.
Antares Instruments, Inc.
Arcweld Mfg. Co.
Audubon Metalwove Belt Div., Manganese Steel Forge Co.

Babcock & Wilcox Co.
Balcrank, Inc.
Balteau Electric Corp.
Banner Welder, Inc.
Barber-Colman Co., Wheelco Instruments Div.
Barer Engineering and Machinery Co., Ltd.
Bausch & Lomb Optical Co.
Beemer Engineering Co.
Chemical Micro Milling Co.
Plastic & Rubber Products Co.
Beryllium Corp.
Binks Manufacturing Co.
Bishop & Co., J.
Platinum Products Div.
Tubular Products Div.
Blakeslee & Co., G. S.
Bliss Co., E. W.
Braeburn Alloy Steel Corp.
Continental Copper & Steel Ind.
Branson Ultrasonic Corp.
Bren Weld Corp.
Brooklyn Steel Warehouse Co.
Brush Beryllium Co.
Pennrold Div.
Budd Co.
Buehler, Ltd.

Canada—Dept. of Trade & Commerce
Carpenter Steel Co.
Alloy Tube Div.
Webb Wire Div.
Chilton Co.
Automotive Industries
Iron Age
Cincinnati Sub Zero Products
Circo Equipment Co.
Cobalt Information Center
Collins Microflat Co.
Columbus Coated Fabrics Corp.
CompuDyne Corp.
Consolidated Vacuum Corp.
Bell & Howell
Consolidated Electro Dinamics
Cooke, Troughton & Simms, Inc.
Cooper Metallurgical Associates
Copperweld Steel Co., Aristoloy Steel Div.
Corrosion Reaction Consultants
Crucible Steel Co. of America
Curtiss-Wright Corp., Princeton Div.

Day Engineering Co., Inc.
Despatch Oven Co.
Maxon Premix Burner
Sunbeam Equipment Div.
Daystrom Inc., Weston Instruments Div.
Dayton Perforators, Inc.

Hamler Industries, Inc.
Cryogenerators Inc.
Harper Electric Furnace Corp.
Harris Mfg. Co., Inc.
Harris Transducer Corp., Ultrasonic Div.
Harshaw Scientific Div., Harshaw Chemical Co.
Hastings-Raydist, Inc.
Hayes, Inc., C. I.
Haynes-Stellite Co.
Heli-Coil Corp.
Heller's Son, Inc., E. G.
Hevi-Duty Electric Co., Como Cast Div.
High Vacuum Equipment Corp.
Robinson Tech. Products, Inc.
Hitchiner Mfg. Co., Inc.
Hobart Brothers Co.
Holcroft & Co.
Hones, Inc., Charles A.
Houghton & Co., E. F.
Howe Sound Co.
Misco Precision Casting Co. Div.
Peerless Roll Leaf Div.
Quaker State Metals Co. Div.
Samuel & Co. Div., Frank
Stamford Rolling Mills Div.

Illinois Testing Labs., Inc.
Alnor Instrument Co.
Industrial Heating
Industrial Press
Machinery
Industrial Publishing Corp.
Power Transmission Design
Precision Metal Molding
Welding Design and Fabrication
Instron Engineering Corp.
Instrument Development Labs., Inc.
International Nickel Co., Inc.
Ionic Electrostatic Corp.
Scientific Electric Inc.
Ipsen Industries, Inc.

Janney Cylinder Co.
Jem Penetrameter Mfg.
Johnson Gas Appliance Co.
Jones & Laughlin Steel Co.

KSM Products, Inc.
Kawecki Chemical Co.
Kester Solder Co.
King Tester Corp.
Kinney Mfg. Div., York Air Brake Co.
Kolene Corp.

Laboratory Equipment Corp.
Lake Chemical Co.
Latrobe Steel Co.
Leeds & Northrup Co.
Leitz, Inc., E.
Lepel High Frequency Laboratories, Inc.
Lindberg Engineering Co.

Magnaflux Corp.
Magnetic Analysis Corp.
Mahr Gage Co., Inc.
Manpro Corp.
Markal Co.
Marquardt Corp.
Martin Engineering Co.
Airmatic Tool Co.
Materials Research Corp.
MRC Mfg. Co.
Matthews & Co., James H.
Merrill Brothers
Metal Finishers, Inc.
Metal Powder Industries Federation
Metalographic
Metlab Co.
Mine Safety Appliances Co.
Minneapolis - Honeywell Regulator Co.
Minnesota Mining & Mfg. Co.
Moore & Co., Samuel
DeKoron Products Div.
Synflex Products Div.
Trans. Products Div.

NRC Equipment Corp.
National Research Corp.

Raytheon Corp.
Reinhold Publishing Corp.
Materials in Design Engineering
Relton Corp.
Working Corp.
Republic Steel Corp.
Reynolds Wire Div.
Riehle Testing Machines Div., American Machine & Metals
Rolock, Inc.
Ross Engineering Div., Midland-Ross Corp.

Scherr-Tumico Co.
Tubular Micrometer Co.
Sherr Co., Inc., Geo.
Selas Corp. of America
Service Hard-Chromium Co.
Service Research & Develop. Co.
Shampaine Scientific Co.
Shampaine Industries Co.
Shaw Instrument Corp.
Shell Oil Co.
Sieburg Industries, Inc.
Small Business Adm.
Smith Corp., A. O., Welding Products Div.
Social Security Adm.
South Chester Corp., Southco Div.
Special Libraries Association
Spee-Flo Co.
Spencer Turbine Co.
Sperry Products Co.
Star Expansion Inds. Corp.
Steco Corp.
Steel City Testing Machines, Inc.
Stimpson Co., Inc., Edwin B.
Stokes Corp., F. J.
Surface Combustion Div., Midland-Ross Corp.
Syntron Co.

Tempil Corp.
Texaco, Inc.
Thomas Publishing Co.
Industrial Equipment News
Thomas Register
Timken Roller Bearing Co., Steel & Tube Div.
Tin Research Institute, Inc.
Torsion Balance Co.
Turco Products, Inc., Chem-Mill Div.

Ulbrich Stainless Steels, Inc.
Union Carbide Corp.
Union Carbide Metals Co.
United Scientific Co.
Unitron Instrument Div.
U. S. Electrical Motors, Inc.
Universal-Cyclops Steel Corp., Refractomet Div.
Vanadium-Alloy Steel Co.
Anchor Drawn Steel Co.
Colonial Steel Co.
Metal Forming Corp.
Pittsburgh Tool Steel Wire Co.
Vanadium Corp. of America
Van der Horst Corp. of America
Vic Mfg. Co.
Wal-Met Alloys Co.
Waldron-Hartig Div., Midland Ross Corp.
Wales Strippit, Inc.
Houdaille Industries Inc.
Washington Steel Corp.
Waukee Engineering Co., Inc.
Wells Mfg. Co.
West Instrument Corp.
Westinghouse Electric Corp.
Wiedemann Machine Co.
Wiegand Co., Edwin L.
Wilson Mechanical Instruments Div., American Chain & Cable Co.
Wyandotte Chemicals Corp.
X-Ray Products Div., Oscar Fisher Co.

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Oct. 17-21, Bellevue-Stratford

Mon. 9:00 a.m.
Physical Metallurgy—I

Constitution and Properties of Ti-Co Alloys . . . F. W. Yakymyshyn, G. R. Purdy, J. Gordon Parr, U. of Alberta; R. Taggart, U. of Washington

Self-Diffusion in Ni Single Crystals . . . A. Messner, R. Benson, J. E. Dorn, Univ. of California

Solubility of Oxygen in Delta Iron . . . E. S. Tankins, N. A. Gocken, Univ. of Pennsylvania

Diffusion of Carbon in Thorium . . . D. T. Paterson, Iowa State U.

Yield Point Phenomena in Ni-Ag Alloys . . . V. A. Phillips, R. B. Jones, General Electric Co.

Mon. 2:00 p.m.
Physical Metallurgy—II

Grey and White Solidification of Cast Iron . . . M. Hillert, Swedish Institute for Metal Research

Laves Phases and AB, Compounds of Transition Elements . . . A. E. Dwight, Argonne

Laves Phases of Hf . . . R. P. Elliott, Illinois Tech

Recrystallization Kinetics of Cold Rolled Iron . . . J. T. Michalak, U. S. Steel, W. R. Hibbard, General Electric

Growth Processes in Recrystallization of Al . . . S. Weissmann, Rutgers University

Tues. 9:00 a.m. Phase Diagrams

Ternary System Cd-Bi-In' . . . E. A. Peretti, Notre Dame

Y-Fe, Y-Ni and Y-Cu Systems . . . R. P. Domagala, J. J. Rausch, D. W. Levinson, Armour Research

Phase Equilibria and Properties of Yt-Ti Alloys . . . D. W. Bare, O. N. Carlson, Iowa State

Cb-C System . . . R. P. Elliott, Illinois Tech

Phase Relations of Mg-Al-Zn System . . . J. B. Clark, Dow

Heats of Formation of Fe-Mn Alloys . . . W. B. Kendall, R. Hultgren, University of California

Tues. 9:00 a.m. Steel—I

Decomposition of Austenite in 4340 Steel . . . E. P. Klier, Catholic U.; T. H. Yeh, I.B.M.

Properties of 410 Stainless Deformed Before and After Transformation . . . Y. Hosoi, Japan National Research Institute; K. E. Pinnow, Penn. State

Effect of Al on Strain Aging and Internal Friction in Steel . . . P. H. Laxar, D. J. Blickwede, J. W. Frame, Bethlehem

Microstructure of 3.25% Si Steel . . . W. C. Leslie, R. L. Rickett, G. Konoval, U. S. Steel; C. P. Stroble, Allegheny Ludlum

Morphology of Proeutectoid Cementite . . . R. W. Heckel, H. W. Paxton, Carnegie Tech

Low Temperature Properties of 4340 Steel . . . P. R. Larson, J. Nunes, Watertown Arsenal

High Temperature Materials

Constitution of Re-Cb Alloys . . . P. Levesque, W. R. Bekebrede, H. A. Brown, Raytheon

Beta Transformation of Ti Alloys . . . E. I. Harmon, Electro Metallurgical; A. R. Troiano, Case Tech

Properties of Ta Alloys . . . F. F. Schmidt, F. C. Holden, H. R. Ogden, R. I. Jaffee, Battelle

Ni Alloys for High Temperature . . . J. C. Freche, W. J. Waters, T. J. Riley, N.A.S.A.

Martensitic Steels for High Temperature . . . A. Kasak, V. K. Chandhok, E. J. Dulis, Crucible

Oxidation of Ta . . . W. D. Klopp, D. J. Maykuth, R. I. Jaffee, Battelle Memorial Institute

Thurs. 9:00 a.m. Nuclear Materials

Solubility of U in Bi; Liquidus Curves for U-Zr-Bi System . . . G. D. Schweitzer, J. R. Weeks, Brookhaven

Alloying to Improve Ductility of Va . . . D. T. Klodt, C. E. Lundin, U. of Denver

Properties of U-Ti Martensites . . . D. L. Douglass, General Electric

Effect of Alloy Additions on Properties of U . . . W. H. Friske, H. E. Kline, M. H. Binstock, Atomics International

Thurs. 2:00 p.m. Embrittlement

Temperature and Microstructure Dependence of Size Effects in Notched-Bend Tests on Steel . . . S. Yukawa, G.E.

Embrittlement of Ni . . . K. M. Olsen, C. F. Larkin, P. H. Schmitt, Bell Telephone

Hot Rolling vs. Brittle Fracture in Steel . . . F. de Kazinczy, Oxelösunds Järnverksaktiebolag, Sweden; W. A. Backofen, M.I.T.

Effect of Induction Tempering on 500° Embrittlement . . . A. Nakashima, J. F. Libsch, Lehigh

Occlusion of H by Hypoeutectoid Fe-C . . . M. Kotyk, H. M. Davis, Penn. State

Occlusion of H by Cold Worked Steel . . . J. E. Werner, H. M. Davis, Penn. State

H Embrittlement in V-Cb Alloys . . . A. L. Eustice, O. N. Carlson, Iowa State

Don't Forget—

ASM Annual Banquet
Thursday Evening, Oct. 20

Awards Luncheon
Tuesday Noon, Oct. 18

ASM Annual Meeting and Campbell Memorial Lecture
Wednesday Morning, Oct. 19

College Alumni Luncheons
Wednesday Noon, Oct. 19

Mon. 9:00 a.m. Inspection of Steel
Metallurgical Microscopy

Electron Microscope in Metallurgical Problems . . . J. Nutting, Cambridge Univ.

Quantitative Metallography . . . E. E. Underwood, Battelle

Microscopic Methods . . . J. W. Spretnak, Ohio State Univ.

Thurs. 9:00 a.m.
Structure vs. Properties—I

Notch Toughness of Unhardened Steel . . . R. D. Stout, E. H. Kottcamp, Lehigh

Fracture Toughness of Steel for Pressure Vessels . . . H. Bernstein, G. C. Young, U. S. Navy

Heat Treat Variables vs. Fracture of Steels . . . P. P. Puzak, U. S. Navy

Strengthening Steels by Deforming Austenite . . . R. A. Grange, J. B. Mitchell, U. S. Steel

Microstructure vs. Corrosion Resistance . . . A. M. Hall, W. K. Boyd, Battelle Memorial Inst.

Thurs. 2:00 p.m.
Structures vs. Properties—II

Composition, Structure and Processing vs. Properties of Fe-Ni Alloys . . . J. Raudebaugh, Int'l Nickel

Properties of Gray and Ductile Irons . . . J. P. Wallace, Case Tech.

APM Alloys . . . R. J. Towner, Alcoa

Refinement of Al-Si Alloy . . . P. Telang, Ford; G. Urdea, Aerojet-General

Properties of René 41 and Astroloy . . . D. P. Moon, W. F. Simmons, Battelle; J. F. Barker, G.E.

Properties of Ti Alloys . . . E. Bohanek, Titanium Metals Corp.

ASM-AEC Conference—Non-Oxide Compounds For Nuclear Fuels

Oct. 17, Bellevue-Stratford

Mon. 9:00 a.m. Uranium Compounds

Introduction . . . M. Whitman, U.S. Air Force

Refractory Fuel Compounds . . . R. F. Dickerson, Battelle

Beryllides Containing Uranium . . . J. P. Smith, General Electric

Uranium Mononitride . . . D. Keller, Battelle

Graphite-Matrix Fuels . . . M. Janes, National Carbon Co.

Mon. 2:00 p.m. Uranium Carbide

Production . . . Z. Shapiro, Nuclear Materials Equipment Corp.

Powder Metallurgy . . . H. Kalish, Olin Mathieson

Skull-Melting and Multiple Molding . . . E. Foster, Battelle

Compatibility With Cladding and Coolants . . . D. I. Sinizer, Atomics International

Zirconium-Uranium Carbide . . . M. G. Bowman, Los Alamos Labs.

Dayton Perforators, Inc.

NRO Equipment Corp.

National Research Corp.

presentation of this invitation.

. . . F. Garofalo, R. W. P. Domis, F. U.S. Steel

Metallurgy in the ments, Applications,

uctical Vehicles . . . J. S. Army
. . . S. B. Levin,

Rocket Motors . . . l, U.S. Army

Control—I

Control . . . W. A. ghouse
Undercooled Metals ker, General Electric
Alloy Ingots . . . J. W. telle

Diffusion—I

gnetic Materials . . . ll, U. of Delaware
n Ag-Au . . . L. Slif- Carolina; W. Mallard,

Plastic Strain . . . R. f Ill.; J. Darby, Ar- nizuka, U. of Arizona

Imperfections, faces (Abstract

Metallurgy—II

s. Stress-Corrosion D. van Rooyen, Wes-

g . . . D. W. McDow- allisin, Int'l. Nickel
teels With Delta Fer- K. Chandhok, E. J.
lot Ductility . . . F. K. Denhard, Armco
of Delta Ferrite . . . Vestinghouse

Control—II

periments vs. Full- ion . . . B. Chalmers,

Solidification of Steel eminos, S. Z. Uram, H. F. Taylor, M.I.T.
Description of So- . . E. L. Foster, B. K. Franklin, Battelle

bstract Session)

Metallurgy in the ments, Applications,

emarks . . . W. J. Ely, ch Office
e Army . . . L. G. Research Office
Materials . . . H. P. ford Arsenal

D. K. Riegger, R. J. Warrick, J. M. Dahl, U. of Michigan

Phase Equilibrium of Nonmetallics in FeO-MnO-MnS-SiO$_2$ System . . . E. H. Silverman, U.S. Steel

Cr vs. S Activity in Liquid Fe . . . N. R. Griffing, G. W. Healy, Union Carbide

Tues. 2:00 p.m. Extremely High Pressures—II (Abstract Session)

Wed. 9:00 a.m. Diffusion Controlled Processes (Abstract Session)

Wed. 9:00 a.m. Metallic Moderators and Cladding Materials—I

Zircaloy Tubing for Cladding Nuclear Fuel . . . R. C. Aumgst, K. M. Haws, P. L. Farnsworth, G.E.

Zircaloy-2 Tubing . . . H. H. Klepfer, C. N. Spalaris, General Electric

Zircaloy-4 . . . J. N. Chirigos, S. Kass, W. W. Kirk, G. J. Salvaggio, Westinghouse

Hydriding Process for Zr Alloys . . . R. E. Westerman, General Electric

Zr Cladding for Pressurized Water Reactors . . . D. L. Douglass, G. E.

Zr Alloys for Cladding Fuel Elements . . . R. K. Wagner, Atomics International

High-Temperature Cladding Alloys . . . J. Collins, J. McGurty, G.E.

APM Products . . . E. G. Kendall, W. H. Priske, Atomics Int'l.

Wed. 9:00 a.m. Gases in Metals (Abstract Session)

Wed. 9:00 a.m. Symposium: Austenite Decomposition—I

Nucleation in Solid-Solid Transformations . . . J. N. Hobstetter, U. of Penn.

Growth in Solid-Solid Transformations . . . J. S. Kirkaldy, McMaster U.

Pearlite Reaction . . . J. W. Cahn, W. C. Hagel, General Electric

Pearlite Formation . . . M. Hillert, Swedish Inst. for Metals Research

Electromicroscopic Study of Pearlite Reaction . . . L. S. Darken, R. M. Fisher, U.S. Steel

Wed. 9:00 a.m. Physical and Magnetic Properties (Abstract Session)

Wed. 2:00 p.m. Refractory Sheet

Dept. of Defense Refractory Metal Sheet Program

Wed. 2:00 p.m. Metallic Moderators and Cladding Materials—II

Diffusion of H in Zircaloy-2 . . . J. Markowitz, Westinghouse

Metal Hydrides . . . W. M. Mueller, J. P. Blackledge, Denver Research Inst.

Properties of Yttrium Hydride . . . E. S. Funston, General Electric

Zr-H System . . . J. B. Vetrano, D. P. Atkins, Atomics International

Properties of Zr Hydride . . . W. M. Mueller, R. L. Beck, Denver Research

Thurs. 9:00 a.m. Precipitation and Dispersed Phases (Abstract Session)

Thurs. 2:00 p.m. Refractory Metals (Abstract Session)

Thurs. 2:00 p.m. Creep, Fatigue, and Fracture (Abstract Session)

Thurs. 2:00 p.m. Powder Metallurgy—II (Abstract Session)

Thurs. 2:00 p.m. Textures, Recrystallization and Recovery (Abstract Session)

SNT Technical Program

Oct. 17-21, Benjamin Franklin

Mon. 9:00 a.m. Inspection of Steel

Quality of 4130 and 4330 Steel . . . D. O'Halloran, Northrup Corp.

Specifications for Steel Inspection . . . E. T. Grabowski, U.S. Steel

Differences in Various Metals . . . J. B. Morgan, Allegheny Ludlum

Anomalies in Steel Inspection . . . W. C. Harmon, Republic

Mon. 2:00 p.m. General Testing

Submarine Steel Weldments . . . N. A. Sinclair, M. Nanda, Electric Boat

Electron Spin Resonance Spectroscopy . . . H. A. Elion, Elion Instruments

Three-Dimensional Presentation of Flaws . . . E. Dugger, W.A.D.D.; G. J. Posakony, Automation Instruments

Bonded Laminates . . . R. O. Huffstetler, Bell Helicopter Co.

Tues. 9:00 a.m. Testing and Quality Control

Practical Quality Control . . . E. R. Ott, Rutgers

Electronics Industry . . . A. W. Wortham, Texas Instruments

Reliability and Quality Control . . . B. J. Cinningham, Minneapolis Honeywell

Wed. 9:00 a.m. Electronics Industry

Philosophy of Testing . . . R. C. McMaster, Ohio State

Mechanisms of Failure . . . L. L. Schneider, Reliability Engineers Associates

Component Part Screening—Multiparameter . . . R. E. Thomas, Battelle

Destructive vs. Nondestructive . . . D. D. Seltzer, Martin

Wed. 9:00 a.m. Power and Nuclear Plants

New Equipment in Plants . . . J. Klapper, Ebasco Services

Piping and Equipment in Nuclear Plants . . . E. C. Miller, Oak Ridge

Detecting Service Failures . . . H. Thielsch, Grinnell Co.

Federation Symposium

Oct. 19, Bellevue-Stratford

Wed. 2:00 p.m. Powder Metallurgy

Sintered Brass . . . V. Tarr, Midwest Sintered Products Corp.

Ceramic Molds . . . A. Mason, D. Forbes, Hamilton Porcelains

Thin-Walled Cones . . . R. Powell, L. Zalesk, Frankford Arsenal

Iron Powder by Fluidized Bed Method . . . A. B. Backensto, Alan Wood Steel

Metal Treating Institute

Oct. 20, Bellevue-Stratford

Thurs. 9:00 a.m. Panel: Heat Treating Components for Space-Age Products

Vacuum Heat Treating . . . R. Krogh, Ipsen Laboratories

Heat Treating Specifications . . . J. Benedict, Benedict-Miller Co.

Ultrasonic Manufacturers Association Program

Oct. 20, Bellevue-Stratford

Thurs. 2:00 p.m. Ultrasonics

Dissimilar Metal Joining by Ultrasonics . . . R. S. Ames, Aeroprojects

Developments in Ultrasonic Equipment . . . M. Damast, Narda Ultrasonics

New Applications . . . A. Valente, Westinghouse

Cleaning Shot-Blasted Strip . . . H. Osterman, Branson

Special Libraries Association—Metals Division

Oct. 20-22, John Bartram Hotel

Thurs. 2:00 p.m. Symposium: Joining of Metals

Inert-Gas-Shielded Consumable-Electrode Process . . . I. D. Holster, Air Reduction

Inert Gas Tungsten Welding in Missiles . . . H. S. Davis, Air Reduction

Silver Brazing . . . D. C. Herrschaft, Handy & Harman

Fri. 9:00 a.m. and 2:00 p.m.

First and second session of ASM Metals Engineering Institute metallurgy course—Fundamental Concepts of Metallurgy

Sat. 9:00 a.m. and 2:00 p.m.

Third and fourth sessions of ASM-MEI course—Advancing Frontiers In Metallurgy

Chilton Co.
Automotive Ind
Iron Age
Cincinnati Sub Ze
Circo Equipment
Cobalt Informatio
Collins Microflat
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Consolidated Vacu
Bell & Howell
Consolidated Ele
Cooke, Troughton
Cooper Metallurgi
Copperweld Steel
Div.
Corrosion Reaction
Crucible Steel Co.
Curtiss-Wright Co

Day Engineering
Despatch Oven
Maxon Premix
Sunbeam Equip
Daystrom Inc., W
Div.
Dayton Perforator
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Detroit Testing M
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Electrohome Tech
Dominion Elect
Radio Heaters
Radyne
Elion Ultrasonics
Elion Instrume
Engelhard Indust
Baker Platinum
Engelhard Chem
Engelhard Hano
Instrument & S
Makepiece Div.,
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Engineered Preci
Exomet, Inc.

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Fuller Co., H. B.,

G.S. Equipment
Gas Appliance S
General Alloys C
General-America
nigen Div.
General Electric
Gray Co., Inc.
Graco Products
Great Lakes Ste
Gries Industries,
Gries Reproducer
Gulf Oil Corp.
Guthery Machin
Spot Welder D

Hacker & Co., In
Reichert Optic
Struers Scienti
Hamilton Watch

...ture . . . F. Garofalo, R. ...tmore, W. F. Domis, F. ...gen, U.S. Steel

... a.m. Metallurgy in the ...equirements, Applications, ...rch

...nd Tactical Vehicles . . . ...lter, U. S. Army
...cations . . . S. B. Levin, ...ny
...ellant Rocket Motors . . . ...Daniel, U.S. Army

...a.m.
...cture Control—I

...ucture Control . . . W. A. ...Westinghouse
...ion in Undercooled Metals ...Walker, General Electric
...n in Alloy Ingots . . . J. W. ...y, Battelle

... a.m. Diffusion—I

...in Magnetic Materials . . . ...rchenall, U. of Delaware
...sion in Ag-Au . . . L. Slif... of N. Carolina; W. Mallard, ...U.
...ous Plastic Strain . . . R. ... U. of Ill.; J. Darby, Ar... C. Tomizuka, U. of Arizona

... p.m. Imperfections, ...d Surfaces (Abstract

...p.m.
...Steel Metallurgy—II

...on vs. Stress-Corrosion ... . . . D. van Rooyen, Wes...
...Rolling . . . D. W. McDow... ...Mihalisin, Int'l. Nickel
...Cr Steels With Delta Fer... . . V. K. Chandhok, E. J. ...rucible
...on Hot Ductility . . . F. K. ...E. Denhard, Armco
...ing of Delta Ferrite . . . ...ull, Westinghouse

...p.m.
...cture Control—II

...le Experiments vs. Full-...roduction . . . B. Chalmers, ...
...onal Solidification of Steel ...C. Flemings, S. Z. Uram, ...arone, H. F. Taylor, M.I.T.
...ical Description of So...ion . . . E. L. Foster, B. ..., C. K. Franklin, Battelle

...p.m.
...–II (Abstract Session)

...p.m. Metallurgy in the ...quirements, Applications,

...ry Remarks . . . W. J. Ely, ...search Office
...in the Army . . . L. G. ... Army Research Office
...or Materials . . . H. P. ...Frankford Arsenal

Sulphide Inclusions . . . L. van Vlack, D. K. Riegger, R. J. Warrick, J. M. Dahl, U. of Michigan
Phase Equilibrium of Nonmetallics in FeO-MnO-MnS-SiO$_2$ System . . . E. H. Silverman, U.S. Steel
Cr vs. S Activity in Liquid Fe . . . N. R. Griffing, G. W. Healy, Union Carbide

Tues. 2:00 p.m. Extremely High Pressures—II (Abstract Session)

Wed. 9:00 a.m. Diffusion Controlled Processes (Abstract Session)

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Electronics Industry . . . A. W. Wortham, Texas Instruments
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Automotive Industries
Iron Age
Cincinnati Sub Zero Products
Circo Equipment Co.
Cobalt Information Center
Collins Microflat Co.
Columbus Coated Fabrics Corp.
CompuDyne Corp.
Consolidated Vacuum Corp.
Bell & Howell
Consolidated Electro Dinamics
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Copperweld Steel Co., Aristoloy Steel Div.
Corrosion Reaction Consultants
Crucible Steel Co. of America
Curtiss-Wright Corp., Princeton Div.

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Despatch Oven Co.
Maxon Premix Burner
Sunbeam Equipment Div.
Daystrom Inc., Weston Instruments Div.
Dayton Perforators, Inc.
Detrex Chemical Ind., Inc.
Detroit Testing Machine Co.
Dixon Crucible Co., Joseph
Dodge Steel Co.
Dow Chemical Co.
Driver Co., Wilbur B.
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Merrill Brothers
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Metal Powder Industries Federation
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Mine Safety Appliances Co.
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Worcester Wire Works Div.
National Steel Corp., Enamelstrip Div.
National Ultrasonic Corp.
New Hermes Engraving Machine Corp.
Newage Industries, Inc.
Nordson Corp.
North American Aviation, Rocketdyne, Div.

Oakite Products, Inc.
Ohio Crankshaft Co., Tocco Div.
Oliver Machinery Co.
Olsen Testing Machine Co., Tinius

Pangborn Corp.
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Parker-Kalon Div.
Pennsalt Chemicals Co.
Penton Publishing Co.
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New Equipment Digest
Steel
Perfection Industries Div., Hupp Corp.
Perkin-Elmer Corp.
Philco Corp., Lansdale Div.
Phillips Mfg. Co.
Picker X-Ray Corp.
Polymer Corp.
Porter Co., Inc., H. K. Disston Div.
Powertron Ultrasonics Corp.
Pyrometer Instrument Co

Radiation Electronics Co.
Div., Comptometer Corp.
Radio Frequency Co.
Ransburg Electro-Coating Corp.

Wal-Met Alloys Co.
Waldron-Hartig Div., Midland Ross Corp.
Wales Strippit, Inc.
Houdaille Industries Inc.
Washington Steel Corp.
Waukee Engineering Co., Inc.
Wells Mfg. Co.
West Instrument Corp.
Westinghouse Electric Corp.
Wiedemann Machine Co.
Wiegand Co., Edwin L.
Wilson Mechanical Instruments Div., American Chain & Cable Co.
Wyandotte Chemicals Corp.
X-Ray Products Div., Oscar Fisher Co.

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MAJOR PRODUCTS OF YOUR COMPANY ____

PLEASE USE TYPEWRITER IF POSSIBLE

PLEASE CHECK DEPARTMENT IN WHICH YOU ARE EMPLOYED

1 ☐ Management
2 ☐ Production
3 ☐ Engineering
4 ☐ Metallurgy
5 ☐ Design
6 ☐ Purchasing
7 ☐ Education
8 ☐ Government
9 ☐ Res. & Devel.
10 ☐ Sales & Adv.
11 ☐ Other

PLEASE CHECK SHOW AREAS WHICH INTEREST YOU

1 ☐ Ferrous Metals
2 ☐ Nonferrous Metals
3 ☐ Nonmetal Engineering Materials
4 ☐ Nuclear Materials and Equipment
5 ☐ Cast Materials, Cutting Off and Forming
6 ☐ Industrial Heating
7 ☐ Cleaning, and Finishing
8 ☐ Welding and Joining
9 ☐ Testing, Inspection and Control
10 ☐ Metals Production and Casting
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TECHNICAL PROGRAMS Presentations of more than 200 papers provide a comprehensive source for latest information on technical metalworking.

Hours: 9:00 A.M. and 2:00 P.M.; see program for details.

SHOW HOURS		
	Monday, Oct. 17	12 Noon to 6:00 P.M.
	Tuesday, Oct. 18	12 Noon to 10:00 P.M.
	Wednesday, Oct. 19	12 Noon to 10:00 P.M.
	Thursday, Oct. 20	10 A.M. to 6:00 P.M.
	Friday, Oct. 21	10 A.M. to 6:00 P.M.

Come to Philadelphia

A metalworking spectacular will unfold at the National Metal Congress and Exposition in Philadelphia the third week in October. A new Steel Arena will symbolize a revitalized Metal Show, streamlined to serve the needs of management and technical specialists in the metals industry. Exhibitors will display new steel products and demonstrate technical advances in ten other categories of metals and materials, along with their methods of fabrication and applications. As a visitor, you will have an opportunity to acquire valuable new concepts of metal processing and a wealth of ideas for product improvement.

The engineering and scientific-technical sessions of the Congress will include the programs of six participating societies in addition to the extensive programs of the A.S.M. Featured will be an A.S.M.-A.E.C. conference on nonoxide compounds for nuclear fuels and a special A.S.M. Symposium for Steel Users which will include sessions on stainless, toolsteels and joining of high-strength steels.

The A.S.M. Metals Engineering Program has been extended to four days to fully cover the fabrication and application of metals. Of particular interest will be sessions on metal joining, failure analysis, materials for the aerospace age, and the effect of microstructure on properties. The A.S.M. scientific program will include an unusually good seminar on strengthening mechanisms in solids and four days of fine Transactions papers.

The Society for Nondestructive Testing has a comprehensive five-day program, including an all-day Educational Clinic. The Metal Treating Institute will have a panel discussion on heat treating components for space-age products and the Ultrasonic Manufacturers Association will feature ultrasonic welding. The Metal Powder Industries Federation is planning a symposium on the production of unusual sintered products. As part of the Special Libraries Association program, a two-day survey course on basic metallurgy will be presented by the A.S.M.'s Metal Engineering Institute.

The American Society for Metals has coordinated this outstanding array of new industrial and engineering technology into another fine Metal Show and Congress. In this 12-page gatefold, Metal Progress presents a complete guide to technical programs and exhibits.

You are cordially invited to come to the Metal Show. More than 25,000 "Metals Men" will benefit from exposure to new engineering ideas. A tremendous effort has been made to make this Show more useful to industry — you and your associates will certainly derive great value from it.

Walter Crafts

PRESIDENT
AMERICAN SOCIETY FOR METALS

42nd National Metal Congress and Exposition

Philadelphia, Oct. 15 through 21, 1960

American Society for Metals.....Headquarters, Bellevue-Stratford

Seminar on Strengthening Mechanisms in Solids, Saturday and Sunday
Technical Sessions, Monday morning through Thursday afternoon
Metals Engineering Program, Monday morning through Thursday afternoon
Conference on Non-oxide Compounds for Nuclear Fuels (in cooperation with Atomic Energy Commission), Monday
Symposium for Steel Users, Tues., Wed., Thurs. afternoon, Convention Hall
Honors and Awards Luncheon, Tuesday noon, Convention Hall
Annual Meeting and Campbell Memorial Lecture, Wednesday morning
Annual Banquet, Thursday evening
National Metal Exposition, Monday through Friday, Philadelphia Trade and Convention Center

Fall Meeting of Metallurgical Society of AIME, sponsored by Institute of Metals Division.....Headquarters, Sheraton Hotel

Technical Sessions, Monday morning through Thursday afternoon
Army Day Luncheon, Monday noon
Institute of Metals Lecture, Tuesday morning
Annual Fall Dinner, Tuesday evening

Society for Nondestructive Testing.....Headquarters, Benjamin Franklin

Technical Sessions, Monday through Thursday
Annual Dinner Meeting, Wednesday evening
Educational Clinic, Friday

Industrial Heating Equipment Association.....(Jointly with ASM)

Technical Session, Tuesday morning

Metal Powder Industries Federation.....(Jointly with ASM)

Technical Session, Wednesday afternoon

Metal Treating Institute.....(Jointly with ASM)

Technical Session, Thursday morning

Ultrasonic Manufacturers Association.....(Jointly with ASM)

Technical Session, Thursday afternoon

Special Libraries Association, Metals Division.....John Bartram Hotel

Sessions and Educational Lecture Series, Thursday through Saturday
Annual Dinner Meeting, Thursday evening
Metals Division Luncheon, Friday noon

Metal Progress

October 1960 . . . Volume 78, No. 4

Symbolic of men and the metals industries, this month's cover — as this month's issue — focuses on the Metal Show in Philadelphia. Design by JERRIE GREEN, a prize-winner in M.P.'s competition for students at Cleveland Institute of Art.

Technical News in Brief

Tensile-Impact Test Reveals Best Hot Working Temperature . . . Higher Molybdenum and Silicon Improve 4330 . . . Arc Heater Raises Gases to Ultra-High Temperatures . . . Aluminum Cans Made by Impact Extrusion . . . New Theory Explains Corrosion of Iron . . . Iron Recovered From Tailings of Sulphide Ores . . . Tungsten Formed at High Velocity . . . Report on Progress in High-Temperature Materials 65

Special Report for Technical Management in Metalworking

How to Get More From Modern Steels 71

Progress in steels means improved materials for many applications. Possibilities with high-strength material . . . carbon, leaner alloy and H-steels . . . leaded grades . . . steels for cold extrusion . . . vacuum processed alloys . . . aircraft and missile alloys . . . nuclear steels . . . metallurgically tailored stainless steels. (A-general; ST)*

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More Parts by Cold Heading 77

Advances in Stainless Steels 81

Progress in Forming Steels . . . How to Make Better Drawings and Stampings, by Paul G. Nelson 85

What forming techniques are best, how can all of the grades of sheet steel be used most economically and how can stamping severity of a part be estimated before production starts? This article answers these important questions as applied to steel forming and discusses steps toward lower production costs. (G3, G4, Q23q; CN, 4-53)

Progress in Welding Steels . . . Vapor-Shielded Arc Means Faster Welding, by R. A. Wilson 96

Vaporization of metal oxides and salts carried in a cored wire electrode provides a shield for the arc in a new welding technique. High operating current and a fast-follow arc characteristics aid in getting welding speeds up to 200 in. per min. (K1d)

Modern Quenching Techniques Make It Easier to Heat Treat Steel 101

Today the metals engineer has at his command a wide variety of quenching mediums from which he can obtain almost any cooling rate that he may need. With the proper quenchant, steels ranging from the plain carbon grades to the high-alloyed stainless types can be readily quenched with little danger of cracking or warping. This article details the specific characteristics of each medium, from brine to air, along with descriptions of equipment. (J26, W28p; ST)

Automatic Quenching of Ring Gears 106

Measuring Quenching Rates With the Electronic Quenchometer, by H. J. Gilliland 111

Materials and Process Applications in the Automotive Industry, by M. F. Garwood 115

An account of recent trends and future prospects in these important areas: aluminum die castings . . . pearlitic malleable iron castings . . . cheaper alloy steels . . . aluminized valves . . . parts from powder metallurgy . . . cold extrusion of steel . . . resistance welding . . . protection against corrosion . . . duplex nickel plate for bright trim . . . better paint finishes . . . plastics for auto parts. (T21, 17-57)

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**The coding symbols refer to the ASM-SLA Metallurgical Literature Classification, International (Second) Edition, 1958*

How service life of a furnace I-beam was increased 400%

Electro-Alloys' knowledge of thermal fatigue lead to a simple solution

As a result of cyclical heating and cooling, heat-treating equipment, trays, rolls, tubes and other furnace components, are particularly vulnerable to thermal fatigue. This failure mechanism is not easily spotted. Therefore, the natural course of user and supplier of heat-resistant castings is to try to strengthen the component through the addition of braces, gussets, tie rods and other restricting members or through making heavier metal sections.

Almost inevitably this procedure results in an even shorter service life. The reason: a greater number of design members and heavier metal sections accelerate thermal fatigue.

An interesting study in thermal fatigue and how it was minimized is shown in the Figures at the right.

I-beam was failing after 4-6 months

The beam, shown in Figure 1, supported tube stock heated for welded tubing. After 4-6 months service, the beam would crack and fail at Area "A".

Preliminary calculations proved that the beam was more than adequate in strength. Therefore, Electro-Alloys engineers concentrated their study on the thermal factors of the furnace operation. As shown in Figure 1, the burners were firing below the beam, and special precautions had been taken to insure that the burner flame did not impinge on the cast-alloy beam. But, as also shown, the flame traveling across the furnace strikes a slanted pier and deflects into the casting at Area A. The high concentration of heat at "A" causes the flange to expand more rapidly than the web. This condition created the failure shown in Figure 2 and in the photographic close-up, Figure 3.

To all intents, the failure had the implications of a weak beam . . . buckling, cracking and downward deformation. The approach to solving this problem could be to increase the metal sections or to add restricting members.

Simple baffle extends beam life 400%

Electro-Alloys solution of the problem was not the design of a new beam but the far simpler design of a loose baffle to fit the beam, see Figure 4. This baffle could take the thermal shock. It was small, flexible and could deform at will without detracting from the strength of the beam.

This simple baffle has lengthened beam life 400%.

Avoiding expensive thermal-fatigue pitfalls

Users and designers of heat-resistant castings are vulnerable, generally, to two pitfalls that lead to losses in service life and operating economy:

a. Too much faith in the calculation of applied stresses as the measure of the casting's ability to withstand service conditions. This is reflected by increasing the size or number of restricting members . . . braces, gussets and tie rods.

b. Assuming that an alloy operating well at 2000° F. will work just as well in a different application where maximum temperature is only 1700° F.

These pitfalls are a natural outgrowth of the lack of information on thermal fatigue, an important cause of heat-resistant casting failures.

Electro-Alloys is recognized as a leading authority on thermal fatigue and high-alloy casting design. Case histories, such as the one reported here, and the widely published test data emanating from the Research Laboratory at Mahwah, N. J., are evidence of this.

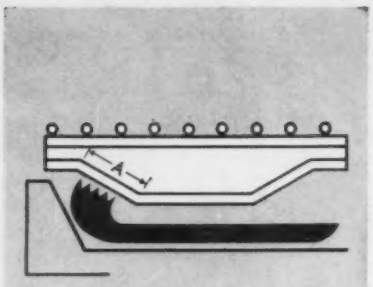

FIGURE 1

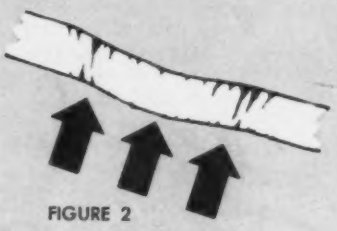

FIGURE 2

FIGURE 3

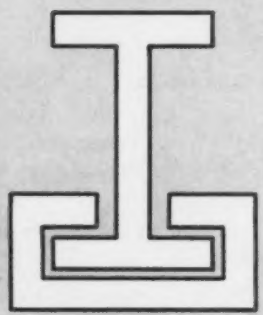

FIGURE 4

● *Most recent of these reports is "The Mechanism of Thermal Fatigue," by H. S. Avery. Copies of this study are available on request. Simply write to Electro-Alloys Division, 20110 Taylor Rd., Elyria, Ohio.*

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Metal Progress

High-Temperature Materials and Nonferrous Alloys

Updating High-Temperature Metallurgy, by E. S. Jones and L. P. Jahnke 131

Since 1958, there has been much progress in the field of high-temperature alloys, particularly at the two ends of the temperature scale. Between room temperature and 500° F., "Ausformed" steels hold the most promise, while tungsten is suitable for temperatures above 3000° F. Titanium alloys, cold worked nickel alloys, and molybdenum and columbium alloys are also improving the high-temperature picture. (Q-general, 2-62; SGA-b)

Progress in Aluminum Alloys 137

New alloys and improved techniques, such as plaster core and vacuum die casting, enable parts to be cast which have better physical properties and a brighter surface . . . New wrought alloys have better weldability . . . APM products provide increased corrosion resistance in severe environments . . . New alloys in 5000 series give brighter finishes . . . Unusual patterns for architectural and other trim applications will come from rolling of composite alloys. (A-general; Al-b, 17-57)

Progress in Copper Alloys 143

"Biofouling" is prevented by mercury added to copper . . . An age hardenable bronze finds use for cold headed bolts . . . Copper plus 0.15% Zr has good stiffness and electrical conductivity . . . Lithium is a useful deoxidizer . . . Tubes of tin-lined copper and copper-lined stainless steel answer corrosion problems . . . Extrusions aid in rotogravure and lock manufacture . . . Shaped rod and bearings are produced by continuous casting . . . Ingenious method for fabricating printed circuits wins Copper and Brass Achievement Award. (A-general; Cu-b, 17-57)

Progress in Magnesium Alloys, by James V. Winkler 146

Two new wrought alloys – ZE 10 A and ZK 21 A – require no stress-relief after welding . . . Precision extrusions minimize machining . . . New casting alloys – ZK 61 A, QE 22 A, EK 31 XA, HM 11 XA – offer improved properties at room and elevated temperatures . . . Better casting methods plus chemical milling give lighter parts . . . A new surface pretreatment allows porcelain enameling on magnesium. (A-general; Mg-b, 17-57)

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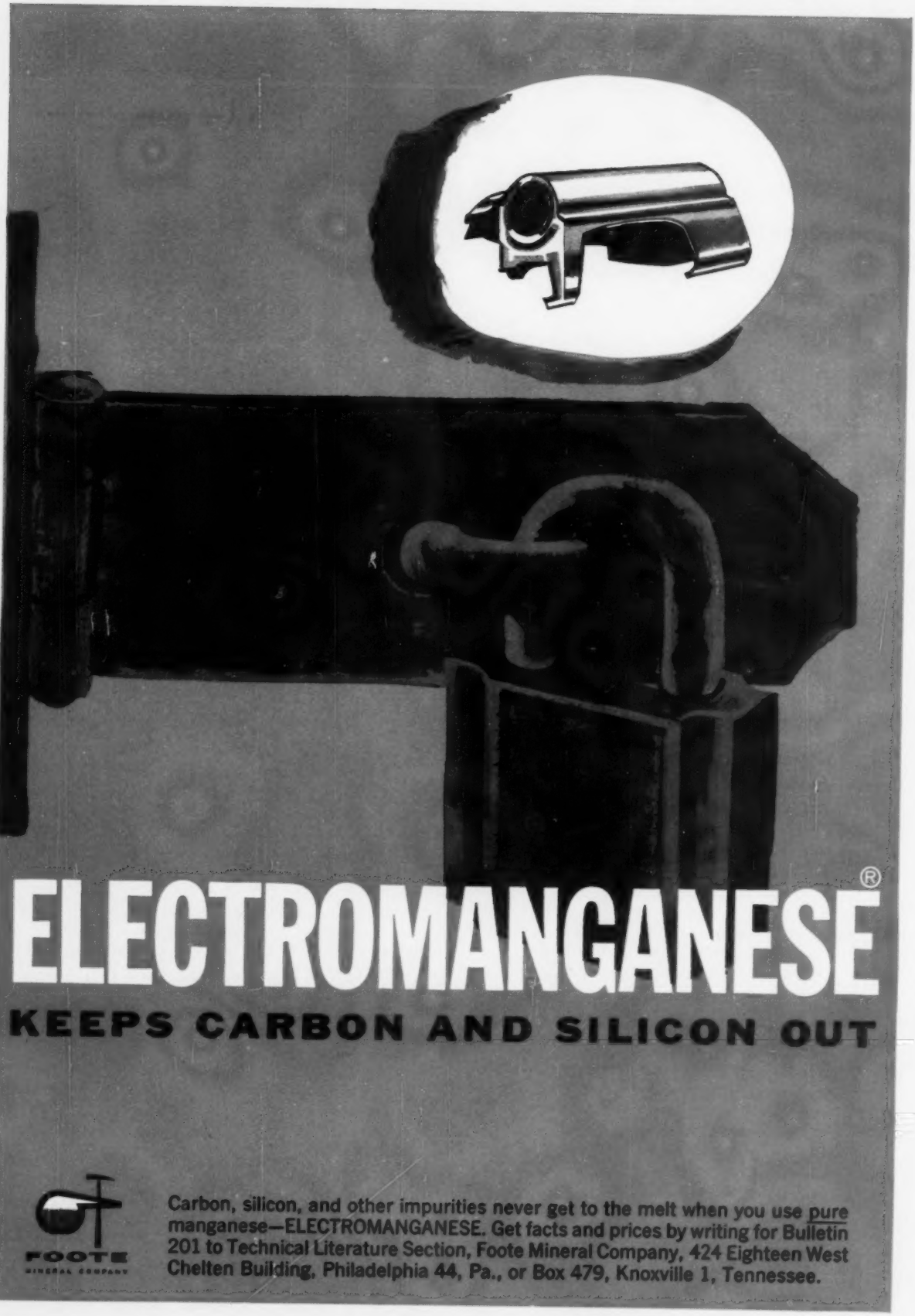
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PRESS BREAKS

In this column recently, we quoted various writings of Marx, Lenin and Stalin which defined Communism as Freedom's devilish enemy in the cold war. Zay Jeffries, in his remarks at the dedication of A.S.M.'s headquarters building last month and while unveiling the bronze bust of the late Wm. H. Eisenman, dwelt upon the Society's function in the present cold war, thrust upon us by the Kremlin, saying "Waging of this cold war is the No. 1 problem of our times and hence it must be high on the agenda of the A.S.M. . . . How can A.S.M. offer maximum assistance in winning the cold war? Certainly by continuing and expanding our traditional and many functions of educating men at all levels in the metals industry. This has already been of important assistance in the technologic explosion of the past two decades. It will be an even more vital factor in the next. Americans simply *must* know what is going on in order to act intelligently . . . The forces of Freedom are stronger than the forces of slavery. There would be no civilization today if this were not so . . . The forces of slavery have been beaten time and time again during the long, hard upward struggle of man. They will be beaten again! On this earth there will be freedom, and man will be at peace with man."

We believe you will find the editorial material developed specifically for this big Metal Show issue – as a "Report to Technical Management" – useful in combating the problems of increased manufacturing costs in metalworking. This theme was prompted by the firm belief of the Editors that in the competitive '60's the technical managers will have more and more to do with keeping the products of their companies competitive through the use of improved technology.

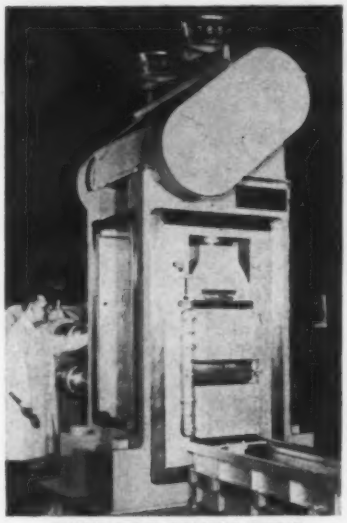
Modern technology is a force which brings together machinery and materials, methods and skills. Our technological progress is, in fact, a national bonanza which has enriched us beyond all expectations. Its potential for further gain is even brighter now than in the past. But a lot of work – both leg and desk – goes into developing articles, such as are presented in this issue, to help you make the most of modern technology. To prepare a single article – take "Modern Quenching Techniques" (p. 101) as an example – the editors telephoned, wrote to and visited with many technical leaders, production men and operators in metalworking and heat treating shops, furnace manufacturing plants, and makers of quenching oils. The great amount of information gleaned from these contacts was evaluated and studied so that the most significant trends and cost-cutting ideas could be presented in our pages.

And speaking of contacts, we will be on hand in A.S.M. Booth 145 in the Steel Arena at the Philadelphia Trade and Convention Center – drop by to see us while you are at the Metal Show. The special gatefold (inside front cover) presents the program in a new easy-to-remove-and-take-with-you package which we believe will assist you greatly in planning your time in Philadelphia. Also, it contains an admission ticket . . . so use it and come to Philadelphia! You will see something new in a Metals and Metalworking Spectacular.

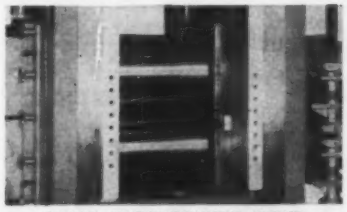
THE EDITORS

LOMA

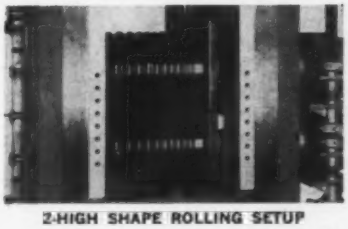
COMBINATION ROLLING MILL



4-HIGH STRIP ROLLING SETUP



2-HIGH SHEET ROLLING SETUP



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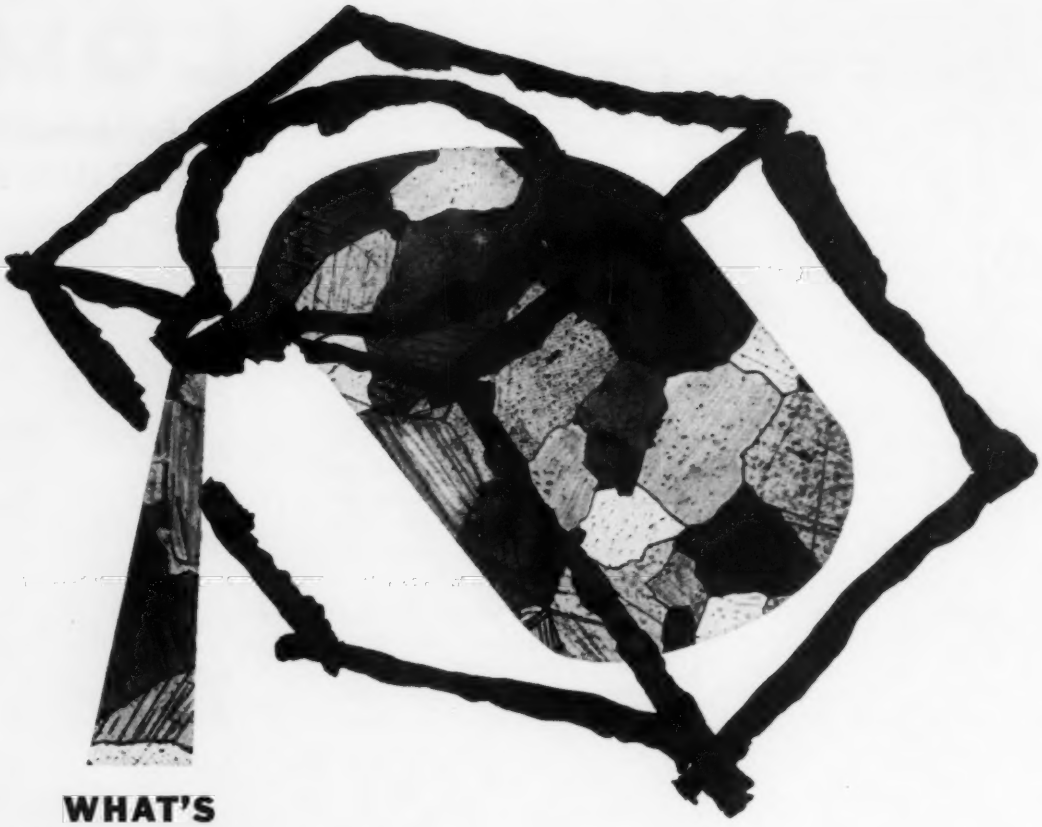

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If you'd like more information on Inductotherm furnaces, write for Bulletin 70. But, for a taste of Inductotherm service, ask to have an engineer call. Inductotherm Corporation, 412 Illinois Ave., Delanco, New Jersey.

INDUCTOTHERM

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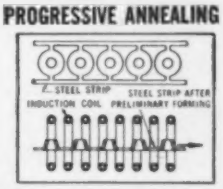
TYPICAL INDUCTION HEATING APPLICATIONS

PLASTIC COATING OF TOOL HANDLES

A production line operation for coating handles of tools at Whitney Metal Tool Co., Rockford, Ill. uses induction heating with excellent results. The handles only are heated by induction to the desired temperature then dipped into a vinyl chloride base coating material for a short period depending upon the thickness of coating desired. The plastic coating formed on the handles is then cured by immersion in a carbo-wax bath.

FORMING OF METAL STRIP FACILITATED BY PROGRESSIVE ANNEALING



Metal forming operations which require intermediate anneals to restore ductility can be facilitated by induction annealing the strip progressively. Diagram illustrates this procedure for partially formed thin austenitic stainless steel strip. The induction annealing operation is scheduled in the production line between two press operations. Metal strip and wire of other materials are also induction annealed in this manner.

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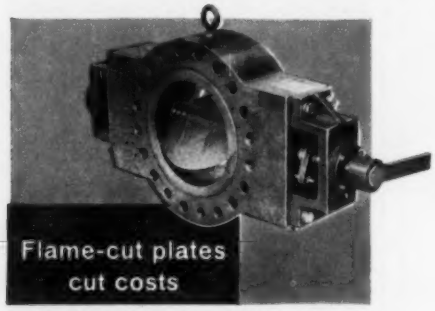
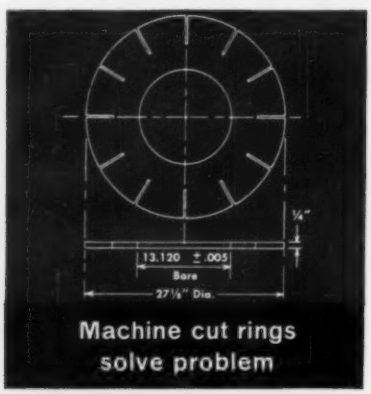


Flame-cut plates cut costs

HIGH REJECTS: Use of flat steel castings for valve bodies, with I. D. ranging from 4" to 60", accounted for increases in costs for this manufacturer. Pattern costs rose because of numerous changes . . . rejects were high due to porosity and other casting faults that showed up only after machining.

HIGH QUALITY: Ryerson recommended using flame-cut plates ranging in thickness from 1" to 8". Results: greater production flexibility, faster delivery, lower cost and a stronger product for this high-pressure service. Tight Ryerson quality control delivered plates of exceptionally clean surface to exact thickness of finished product, requiring little machining.



Machine cut rings solve problem

PLATES REQUESTED: Ryerson was asked to bid on supplying ¼" Type 410 stainless in 27⅛" square plates. Material was to be used for orifice plates for 16" burner, subjected to elevated temperatures.

RINGS RECOMMENDED: Going beyond material specs, the Ryerson representative found that the customer intended to cut plate into 27⅛"-diameter rings with 13.120" bore—and then mill 12 slots in outer diameter for expansion relief. Knowing the application, Ryerson recommended supplying machine-cut rings in which slots could then be punched rather than milled. Production savings enabled switching to Type 304 at less cost than Type 410 with slots milled.

Look at these random examples and see how Ryerson Metalogics sparks real savings by continually searching for and suggesting new materials, methods and techniques.

The broadest experience anywhere combines with the widest range of stocks available to offer you unbiased recommendations on the best material for any job—be it steel, aluminum or plastics. Always the right metal-fabricating machine, too—for Ryerson is the nation's largest distributor.

Your Ryerson representative is "Metalogics-trained" to help you *value-analyze* selection, fabrication and application problems. Get his constructive ideas soon, and see how he can help you select and apply material from our vast stocks. It's the "Metalogical" thing to do.

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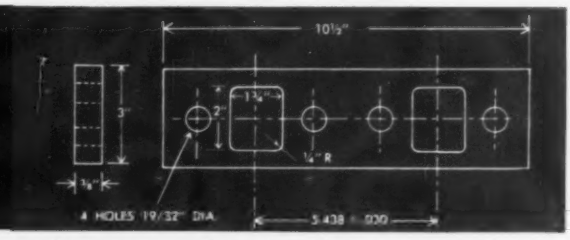
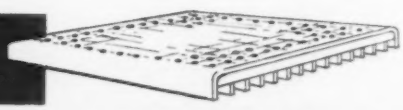


PROBLEM: Muffler manufacturer required accurately finished mounting plates made from ⅜" x 3" bar. Cutting bars to size, burning 1¾" x 2" holes and drilling four 19/32" holes proved time-consuming and expensive.

SOLUTION: Ryerson recommended that they eliminate cutting, burning and drilling operations by stamping the part from Ryerson forming-quality plate. One operation instead of three cut costs $100.00 per thousand pieces and quickly justified the small initial investment in dies.

Suggestion saves 85%



ASKED FOR: Customer wanted 1" hot rolled plate to cover about 80' of 24" open trench. Plate was to be cut into 24" x 27" segments—each containing 900 ⅜" holes to filter the product.

RECOMMENDED: After studying application and cost, Ryerson recommended a design combining perforated light plate, formed to channel shape, and grating for structural support. Ryerson experience and imagination saved 85% of the original cost.

Soft touch on fabricating sheets

THE NEED: Cold rolled sheets that would take severe forming and retain smooth, dull surface for high lacquer finish. Sheet quality was found on inspection to vary widely from one shipment to the next, causing variations in forming and finishing operations . . . high reject rate.

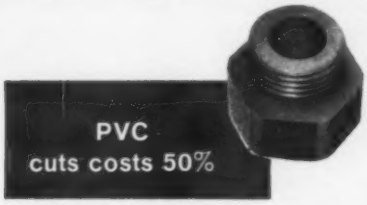
THE ANSWER: The Ryerson representative showed how our stringent quality controls would assure consistent quality on every shipment so that forming and finishing could be standardized for better results . . . lower production cost figures.

ACTION

Production upped 30%

BEFORE: Job shop was using MT 1015 tubing in the manufacture of this coupling. Machinability was satisfactory, but rising costs of operation led to a search for ways to economize.

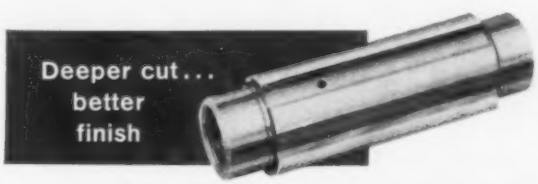
AFTER: Careful study by the Ryerson representative brought about a change in material. He recommended using Ledloy® 170 tubing, which increased machining speed to 170 s.f.m. and stepped up production 30%. Ryerson's stocks include the widest range of fast machining alloys—types and sizes to fit your every need.



PVC cuts costs 50%

OLD WAY: A screw machine shop used nylon in the manufacture of nipple adapter and coupling nuts—until a Ryerson representative came on the scene.

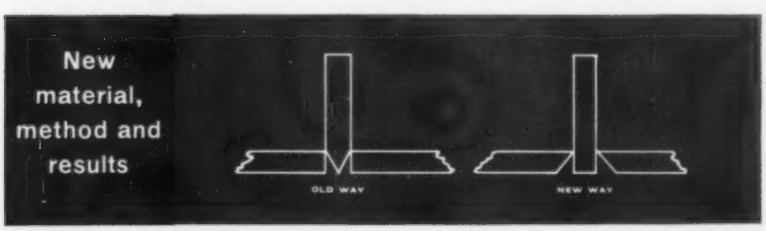
NEW WAY: At his suggestion, they changed to Ryertex-Omicron PVC—cut costs 50%. PVC machined better—to closer tolerances, with improved finish . . . ran faster without "gumming." Note exact cutting of threads and barbs. Threads fit perfectly.



Deeper cut... better finish

SEARCH: Complicated machining of a carbide grade gear shaft included cuts up to ½". It was discovered that required machining was too slow with the steel chosen for the job.

ANSWER: Rycut® 40 was recommended by the Ryerson representative. This free machining alloy fit the situation perfectly. The company found that Rycut 40 machined at 250 s.f.m., gave a better finish, increased tool life, and lowered total per-piece cost. An alloy in the Rycut series may well lower your costs.



New material, method and results

OLD: Rows of vertical aluminum grid members were attached to an aluminum base plate by notching the grid members and welding. (2024-T3 aluminum plate was used.) However, upon cooling, welds fractured—causing a high reject rate on this assembly.

NEW: A Ryerson representative suggested undercutting the base plate (as shown) instead of the grid members. This exposed a greater area to heat and permitted a larger deposit of weld material. Another Ryerson suggestion: change material to 5052-H34 aluminum, which responds better to welding operations.

Longer-wearing bearing

5-DAY LIFE: The sheaves that guide the enormous digging buckets of underwater dredges take a very severe load. Bronze bearing in the sheaves had to be replaced every four or five days.

5 MONTHS, SO FAR: After discussing the problem with a Ryerson man, the chief engineer decided to try a bearing made of Ryertex. The change was made, and five months later hardly any wear was noticeable! With its low friction coefficient, Ryertex is nonbinding, even on itself.

2 metalworking machines for the price of 1

A fabricator of stainless steel kitchen equipment was recently in the market for a new squaring shear. The one under consideration had a gap-type frame which would enable him to do an important notching operation—necessary for certain sink tops. After careful study, a Ryerson machinery specialist recommended *two* pieces of equipment instead of one at no increase in total cost. The first, an underdriven shear. The second, a universal-type sheet metalworking machine that would do the required notching, plus many other jobs—adding versatility to the entire operation.

PRODUCTS IN STOCK

STEEL—carbon, alloy, and stainless steel—bars, structurals, plates, sheets and strip, tubing, etc.

ALUMINUM—sheet (including new building sheet), plate, coils, rod and bar, tubing and pipe, building products, etc.

INDUSTRIAL PLASTICS—Ryertex-Omicron PVC in all forms. Also Ryertex® laminated phenolic plastics for bearings.

METALWORKING MACHINERY—the broadest line available from a single source for every kind of metal fabrication. Also specialized line of material handling equipment.

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Circle 1578 on Page 48-B

AT HOME IN THE ATOMIC AGE...

Matter of fact, stainless steel is more at home in these demanding times than ever before. Rigid requirements in modern components—rather than restricting the use of stainless—have opened an even broader market for this versatile metal. Its remarkable durability and superior resistance to corrosion and heat make stainless all but indispensable in the construction and operation of atomic energy plants. Eastern is proud to have a share in this vital activity.

Eastern is the world's largest exclusive producer of stainless steel sheets and plates. Sold through steel service centers coast to coast.

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Stainless steel sheets, plates, strip, coils

Above: Schematic drawings show how nuclear fission occurs. One atom becomes two, releasing energy.

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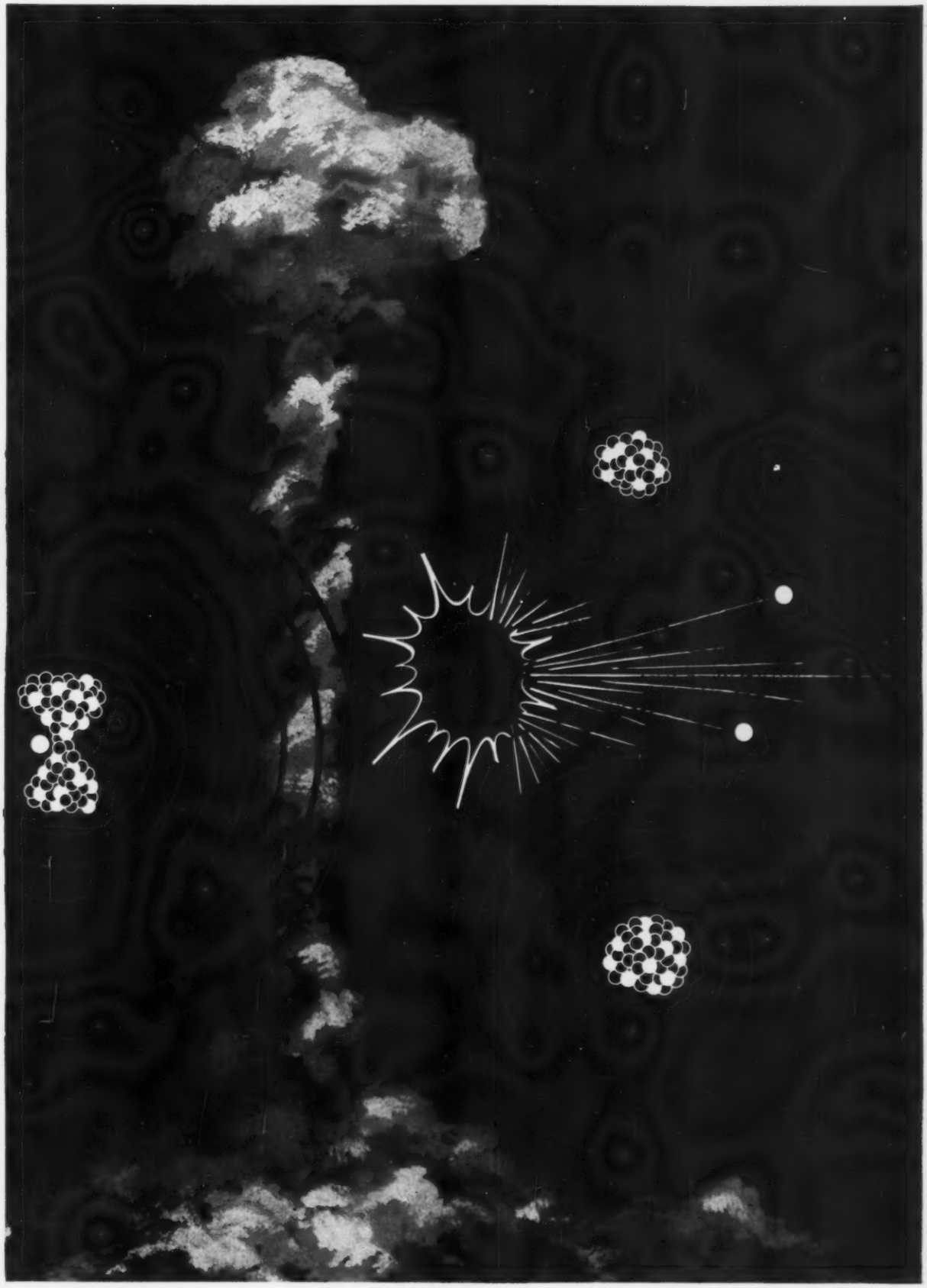
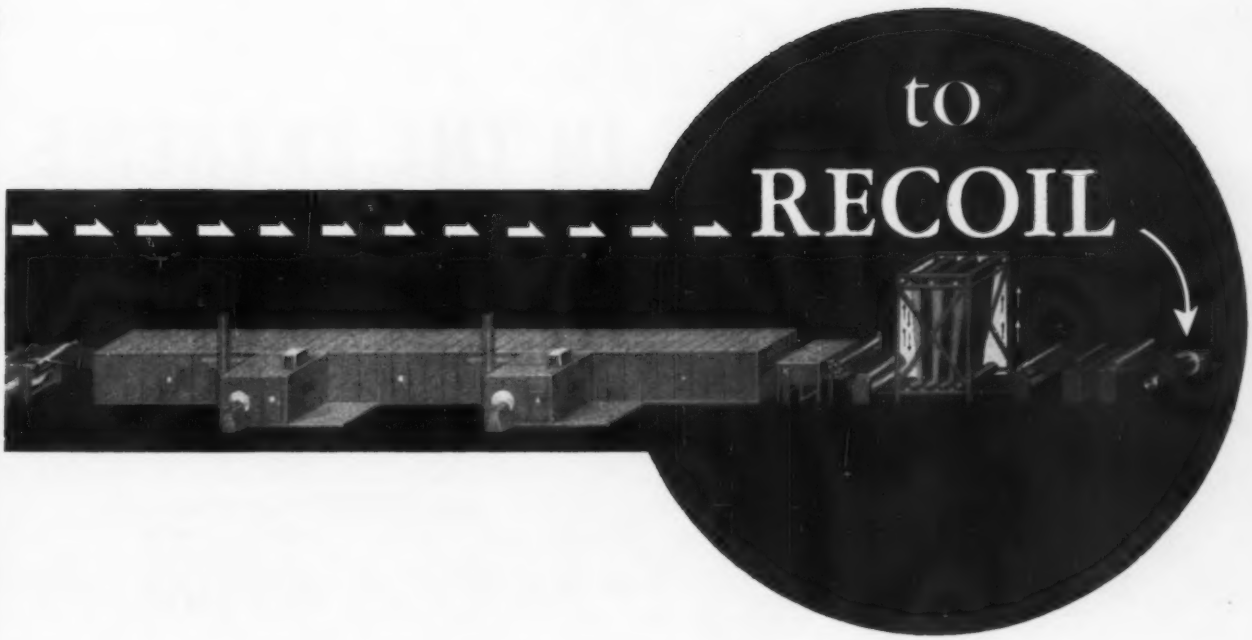


Circle 1579 on Page 48-E

THE ROSS/WALDRON STRIP COATING LINE

high production machinery for quality coating of aluminum and steel strip

Plan now to visit us at Booth 1540 at the Metal Show. We will be glad to give you all the latest information on metal strip coating.



Selecting a Ross/Waldron Strip Coating Line for aluminum, steel, tin plate or any other metal means you have a *single source* responsible for the complete line. Every piece of actual processing equipment is made to the same uniformly high specifications. There are no weak links. Result? Less down-time—more production and the highest quality.

Write for Bulletin RW-500, or our reprint entitled "Continuous Coating of Aluminum or Steel Strip."

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Circle 1580 on Page 48-B

DURABLE IN THE EXTREME

...parts produced from Republic VACUUM-MELTED Metals

A leading manufacturer of ball bearings uses Republic Type 52100 Vacuum-Melted Alloy Steel in bearings produced for aircraft and missile applications. This steel provides excellent resistance to erosion, corrosion, abrasion, and impact. The alloy is supplied to the manufacturer in bars. It is then drawn into wire rods, annealed, drawn to size, sheared into slugs, forged, heat treated, rough ground, tempered, finish ground, and polished.

Produced by the consumable electrode process, Republic Vacuum-Melted Metals offer higher mechanical properties—ductility, tensile strength, and longer fatigue life—with nonmetallic inclusions reduced in number and size. Republic can deliver these metals in quantity on time, and in a wider range of sizes and conditions than ever before possible.

Our metallurgists will quickly help you select, apply, and process vacuum-melted metals: *super alloy steels, constructional alloy steels, high strength alloy steels, bearing steels, stainless steels, titanium,* and *special carbon steels.* For complete information, contact your nearest Republic sales office or return the coupon.

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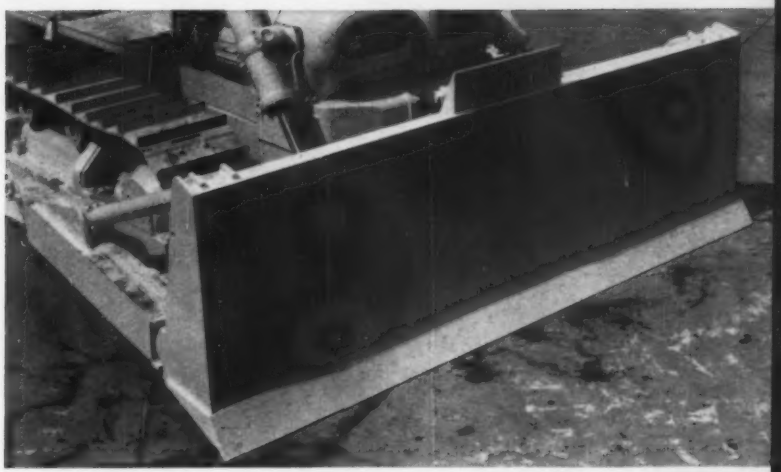
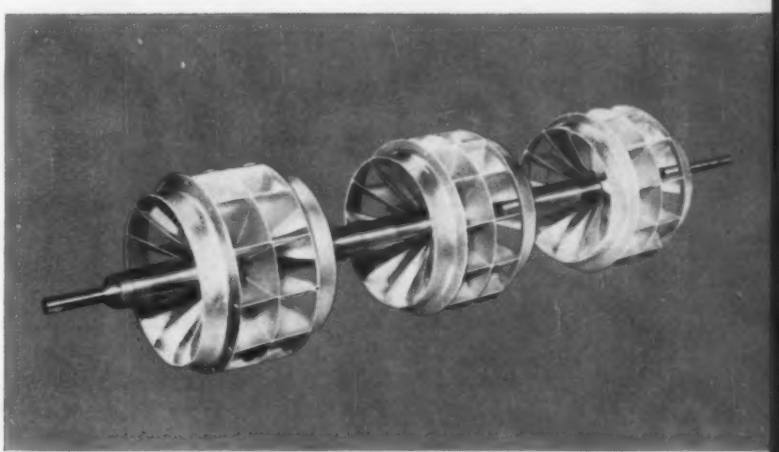
REPUBLIC VACUUM-MELTED METALS are produced in 18- to 32-inch diameter ingots weighing from 4,000 to 20,000 pounds. These can be processed into billets, sheets, bars, strip, and wire to meet your precise requirements.



EXTREME TOUGHNESS: Grader and bulldozer blades are produced from Republic Hot Rolled Special Sections by Bucyrus Blades, Inc., Bucyrus, Ohio. Special analysis steel—proved on the job—gives uniformly high impact- and wear-resistance. Our technical people will be happy to show you how Republic's wide range of special section sizes and contours can be adapted to your particular product requirements.



CLOSE-TOLERANCE CONCENTRICITY: Buffalo Forge Company uses Republic ELECTRUNITE® Mechanical Tubing in the production of rotor shafts up to 94" long. Turning at 1,110 rpm, these shafts require exact balance to maintain high operating efficiency. Close-tolerance concentricity of ELECTRUNITE meets requirements without costly machining. ELECTRUNITE Mechanical Tubing is available in carbon and stainless steel. Mail coupon for details.

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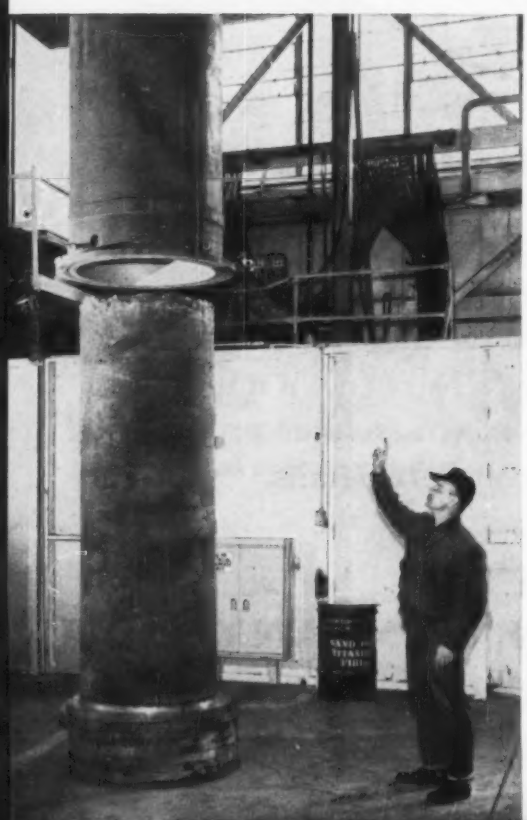

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- ☐ ELECTRUNITE Mechanical Tubing
- ☐ Have representative call to discuss Special Section requirements

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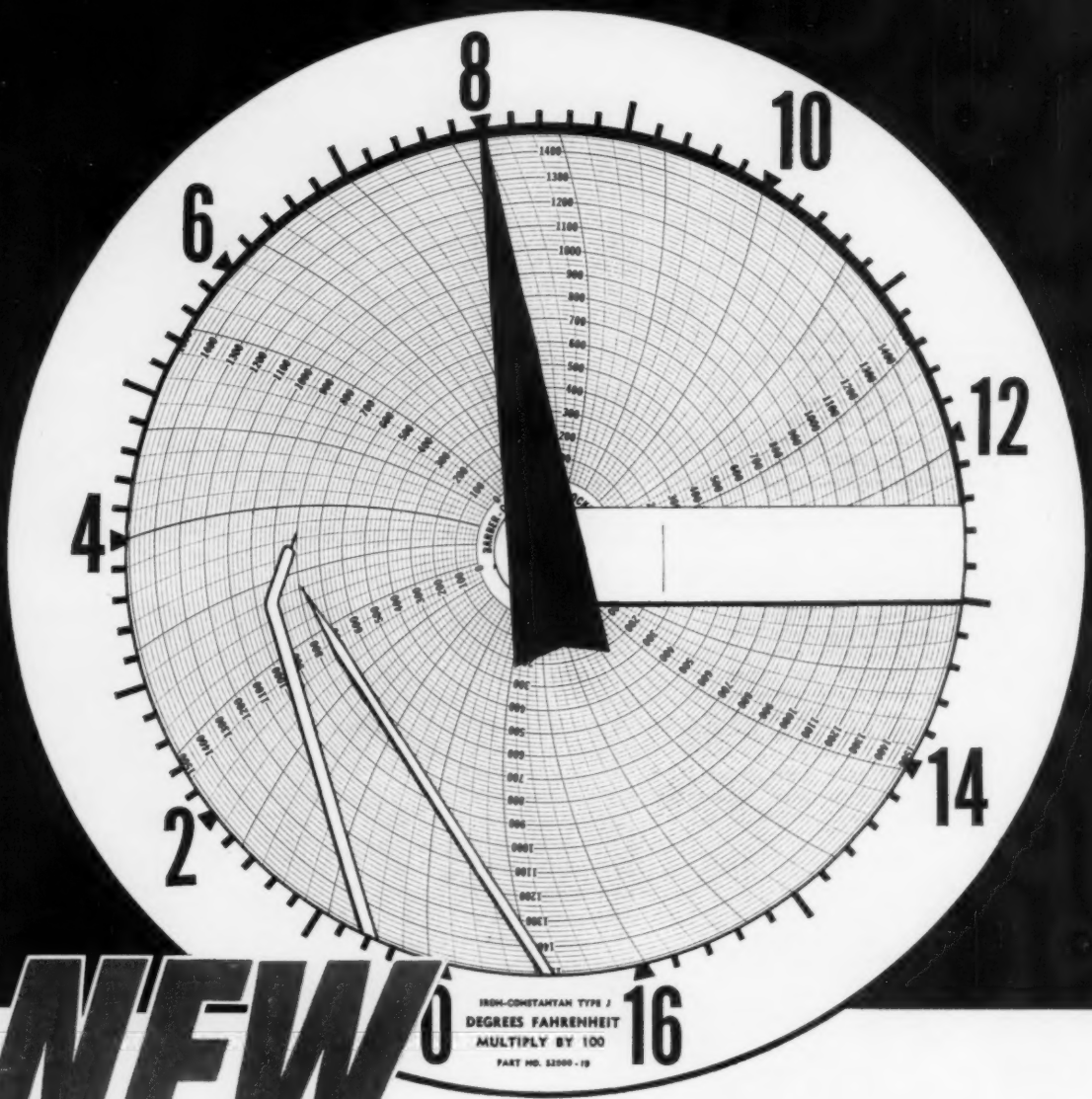
Circle 1581 on Page 48-B



NEW WHEELCO "DOUBLE-O"

Behind this dial, Wheelco presents a *new* instrument line at industry's most attractive price . . . the Double-O Models Recording and Indicating Controllers. Wheelco has integrated the most popular and the same famous Wheelco quality features into one full-size (not a miniature) electronic potentiometer controller line. And now, a volume production savings is passed on to you. Write today for complete details.

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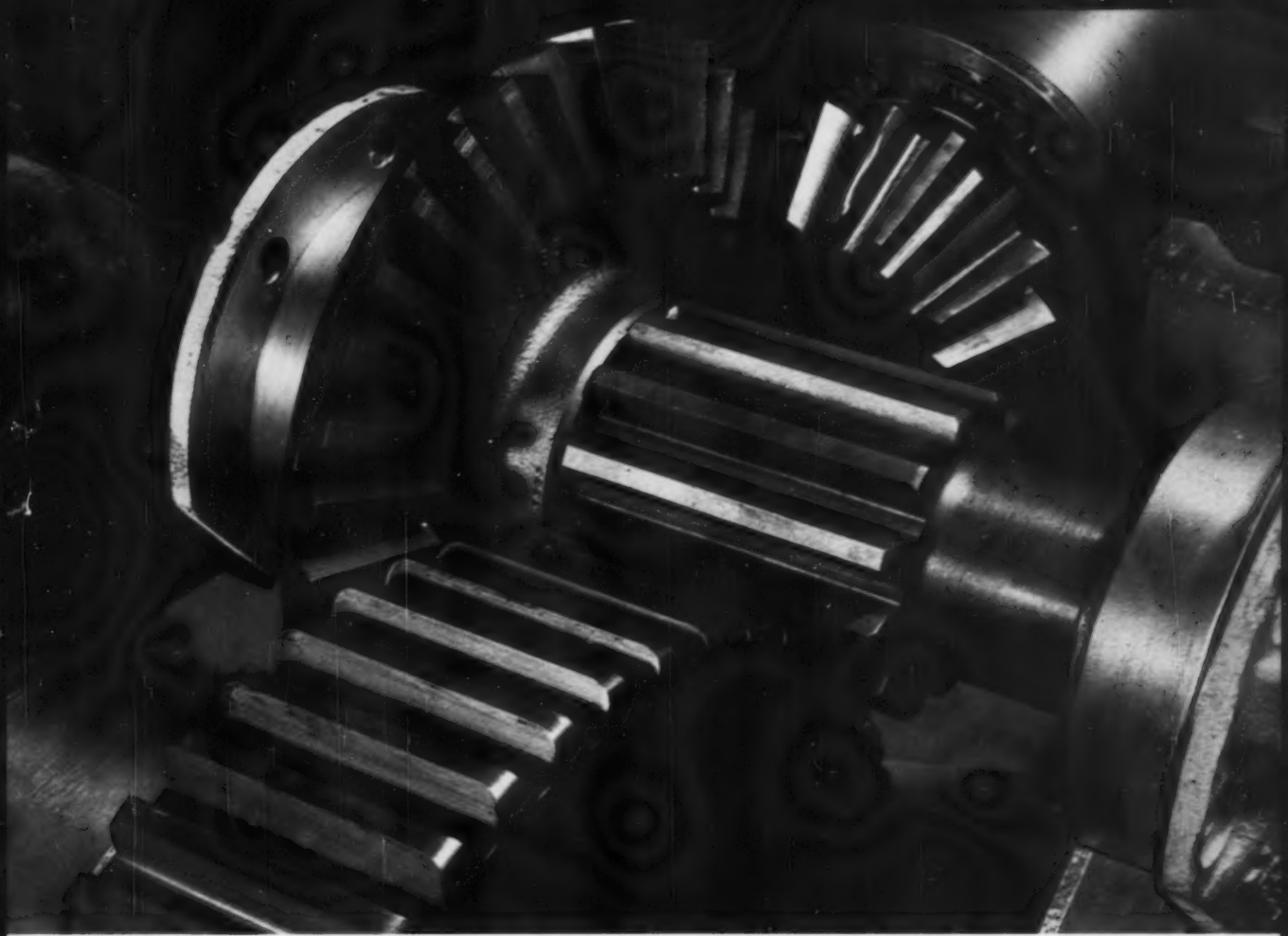

These gears drive the cutting head of a Lee-Norse continuous coal miner. They have superb toughness to resist impact and wear. They're made of AISI 4820, 4320, and 4817 alloy steels.

These teeth are not for chewing

Gear teeth aren't supposed to chew anything (especially each other) because it's so very *expensive.* A broken ten-dollar gear can cost a thousand dollars in down time—so it pays to use the very best alloy steels for gears and other highly stressed parts.

When we make USS Alloy Gear Steels, every production step has one purpose: to prevent failure in actual service. These premium steels forge and machine without distortion. They are dimensionally stable, and they come in the widest possible range of mechanical properties. Be sure to specify USS Alloy Gear Steels: Carburizing steels for toughness, shock and wear resistance; through-hardening steels for heavy loads at slow to medium speeds; cyaniding and nitriding steels for wear.

For information or metallurgical assistance, call our nearest sales office or United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

USS is a registered trademark

This mark tells you a product is made of modern, dependable Steel.

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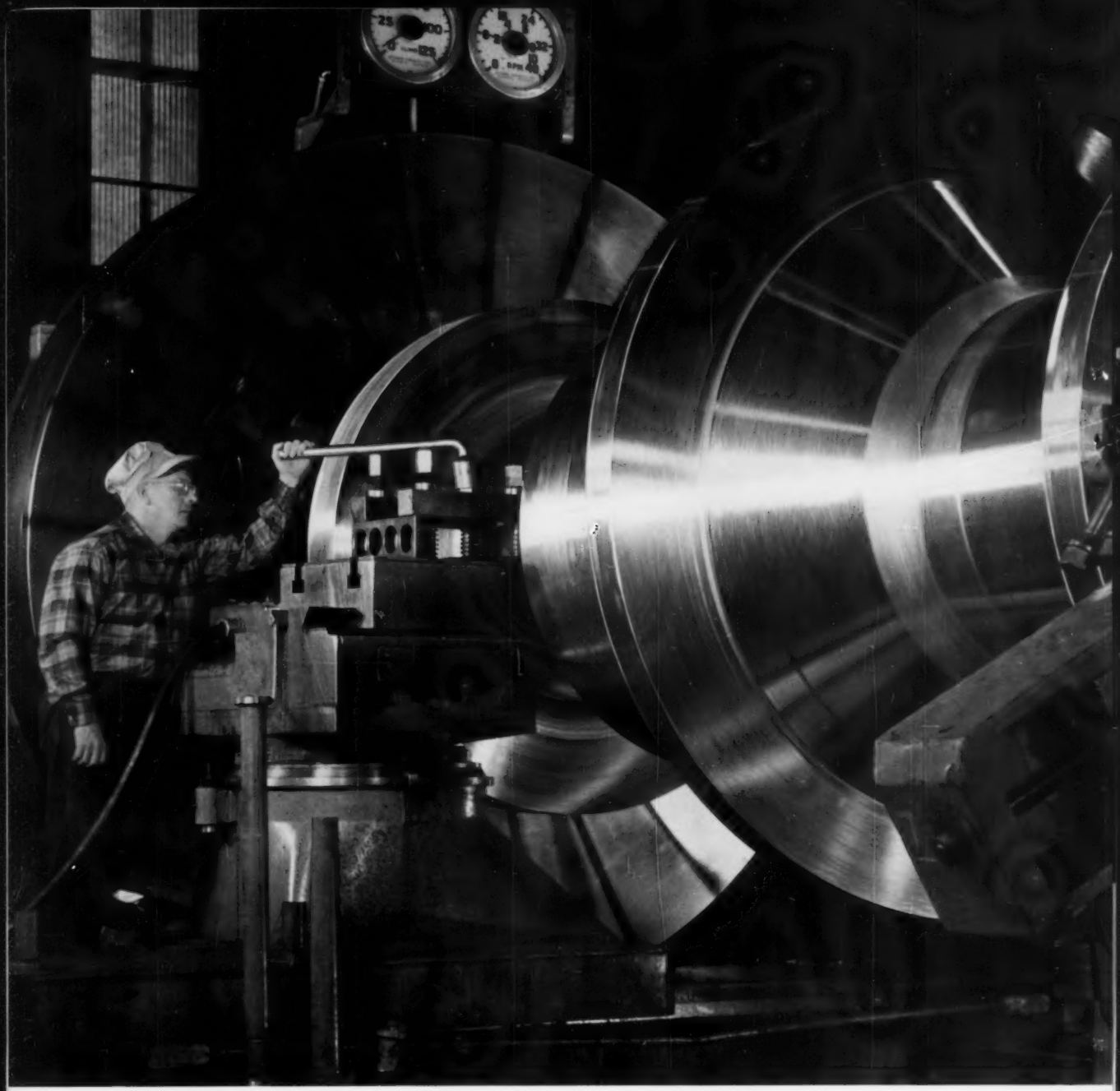
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Supply—Steel Service Centers
United States Steel Export Company

United States Steel

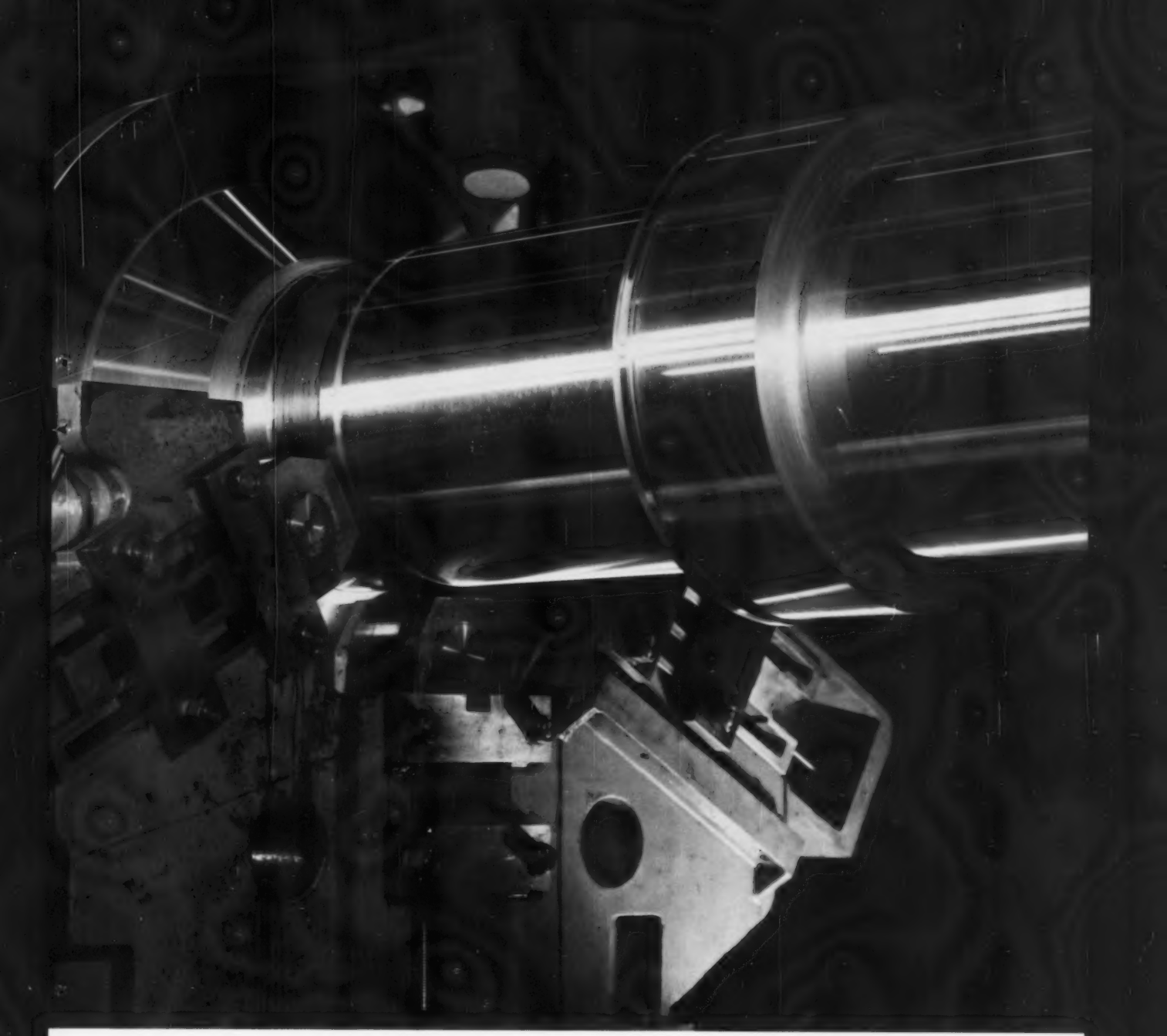
USS



This USS Forging will perform in Spain

In the main picture, you see a water wheel shaft as it was rough machined in the 120″ lathe at U. S. Steel's Homestead Works. When this USS Quality Forging was completed, it was sent to a major power plant builder where it became a part of a hydro-electric facility which will be erected in Spain. It is used as a connecting shaft between the impeller and the electrical generator. When you consider the high torque imposed upon it, you realize that this forging must be as nearly perfect as men can make it.

The forging was made from carbon steel cast into a 130″ diameter ingot, smooth forged, heat treated, and rough machined as you see it here. The forging was tested and inspected throughout its processing. As shipped,



it weighed 126,000 pounds. Five other similar forgings were delivered to the power plant builder—a total of 378 tons of water wheel shafting.

The gentleman shown at the left is positive that these forgings will perform satisfactorily. As Manager of Forgings Metallurgy at U. S. Steel, G. T. "Ted" Jones has a real and personal interest in the quality of USS Forgings. Water wheels, as well as turbine and generator forgings, are produced to most exacting specifications, but they are all capably handled by U. S. Steel forging experts. These same men can handle your forging requirements. If you would like additional information about USS Quality Forgings, write to United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

USS is a registered trademark

This mark tells you a product is made of modern, dependable Steel.

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USS

Titeflex, Inc., Meets Aircraft Fuel, Lubrication and Hydraulic Line Specifications with

HANDY & HARMAN BRAZE 541

Titeflex operator brazes assembly with torch and hand-fed Handy & Harman Alloy BRAZE 541. *Titeflex is unique in that it makes flexible hose assemblies from raw material to end product—"From End to End, Inside and Out, made RIGHT In Our Own Plant."*

This Springfield, Massachusetts, manufacturer of aircraft and missile fuel, lubrication and hydraulic lines finds that silver alloy brazing with Handy & Harman BRAZE 541 meets rigid operating requirements "all the way down the line."

The tubing and fittings of many of the wide range of assemblies made by Titeflex are 321, 316 and 347 stainless steel and Monel. Brazing is a hand torch, wire and HANDY FLUX operation.

BRAZE 541 is a plastic alloy which melts at 1325° F and flows at 1575° F. Its strength—in shear—at elevated temperatures is 21,500 psi at 500° F and 15,000 psi at 750° F. This alloy's ductility in resisting stress and vibration is very high and its resistance to oxidation and corrosion is equally impressive. The composition of BRAZE 541 is 54% silver, 40% copper, 5% zinc and 1% nickel. It meets AMS Specification 4772.

Aircraft and missile component manufacturers and fabricators are finding—to their and their products' benefit—that Handy & Harman silver alloy brazing is the full and *final* solution to their metal-joining problems. BRAZE 541 is but one of a large family of Handy & Harman alloys, for both low and high temperature applications. We would like to more fully acquaint you with BRAZE 541 and with the advantages that come naturally to silver brazing as a metal-joining (both ferrous and nonferrous) method. Handy & Harman, 82 Fulton Street, New York 38, N. Y.

FOR A GOOD START: BULLETIN 20

This informative booklet gives a good picture of silver brazing and its benefits... includes details on alloys, heating methods, joint design and production techniques. Write for your copy.

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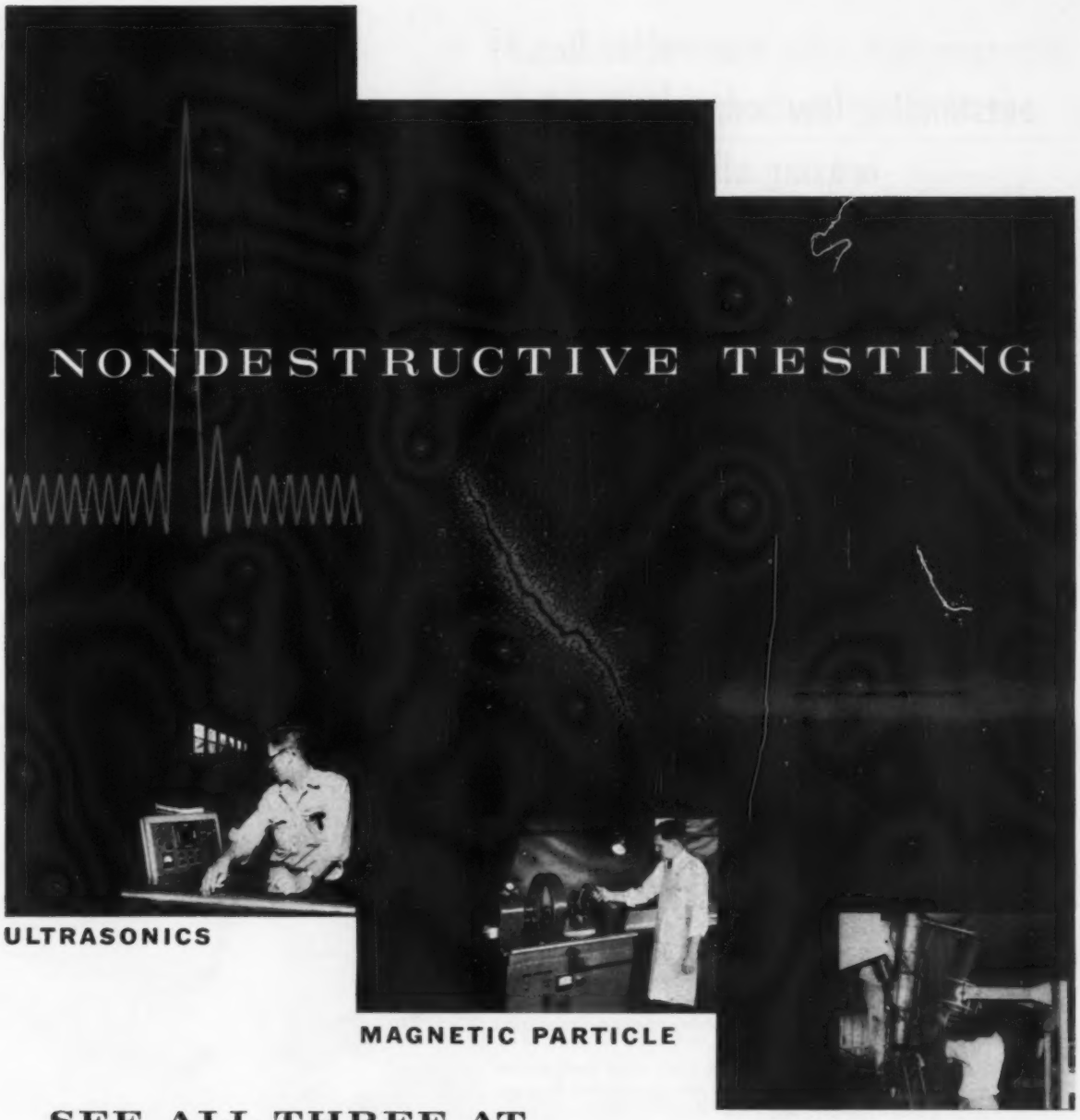
Circle 1583 on Page 48-E



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Demonstrations of the newest developments and techniques in nondestructive testing will be featured in the Sperry Products Company booth at the Metal Show in Philadelphia this October. The addition of Sonoflux® magnetic particle equipment and Triplett and Barton Industrial X-Ray to Sperry's line of ultrasonic test instruments and systems provides Sperry with the most versatile range of nondestructive testing devices and techniques available from one source.

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Circle 1584 on Page 48-B

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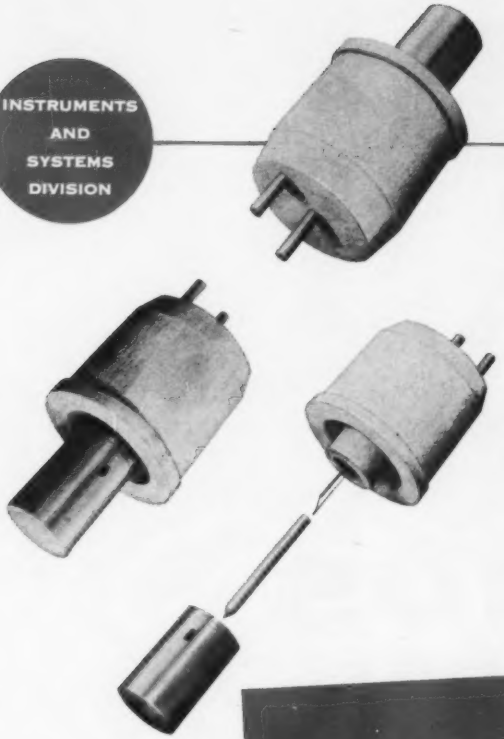
INSTRUMENTS AND SYSTEMS DIVISION



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Immersed into the body of molten metal, this thermocouple reaches the metal temperature within seconds, the output signal being recorded to give a continuous temperature record. After immersion, the thermocouple unit is easily removed from its socket in the portable iron pipe in which it is used, to be replaced with a new one for the next reading.

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"One test is worth a thousand expert opinions."™

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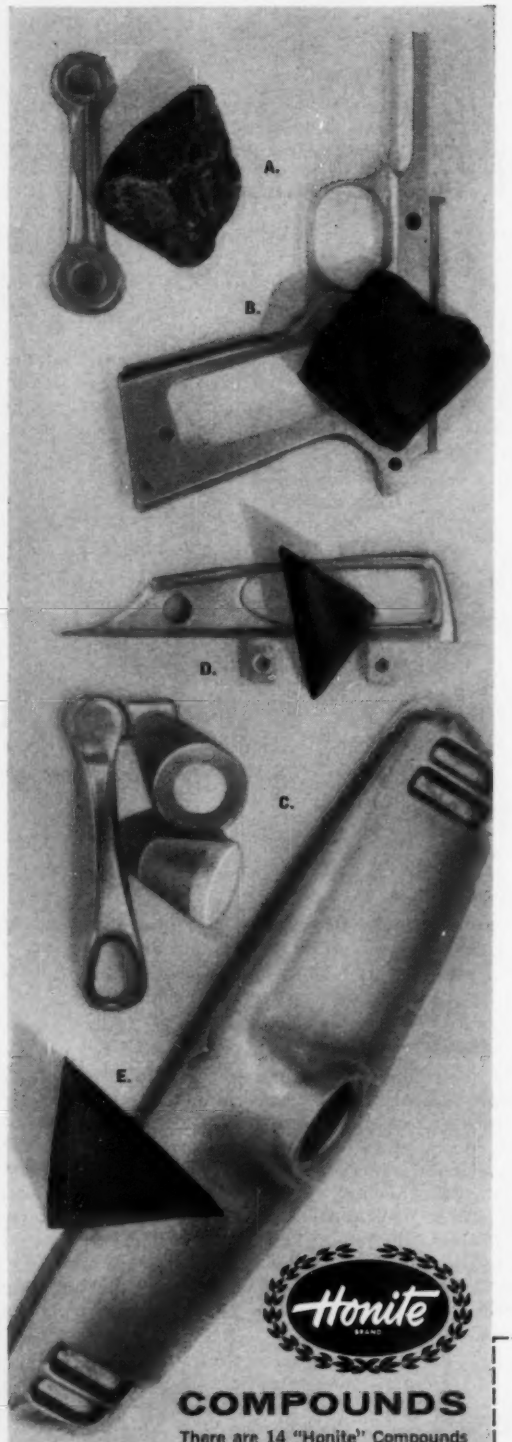
TROY LAUNDRY MACHINERY • RIEHLE TESTING MACHINES • DE BOTHEZAT FANS • TOLHURST CENTRIFUGALS • FILTRATION ENGINEERS • FILTRATION FABRICS • NIAGARA FILTERS • UNITED STATES GAUGE • RAHM INSTRUMENTS • LAMB ELECTRIC COMPANY • HUNTER SPRING COMPANY GLASER-STEERS CORPORATION

Circle 1586 on Page 48-8

NEW PRODUCTS • NEW PRODUCTS • NEW PRODUCTS •



3M gives you the keys to

BETTER BARREL FINISHING

with a complete line of "HONITE" Brand Products

Now from 3M research come the most efficient barrel finishing materials. A complete line of abrasive media and compounds to meet all your deburring, descaling, deflashing, coloring and burnishing needs and perform precision surface finishing.

For free advice on selection of media, compounds and recommendations on equipment see your "Honite" Field Engineer or Distributor. He is trained and experienced to help you. He'll be happy to sample process your materials or conduct a "Honite" demonstration.

"HONITE" MEDIA

These five types of "Honite" Brand abrasive media are recognized as the best and most complete line for barrel finishing.

A. **"HONITE"** – A tough, low cost, long-wearing natural stone containing a micro-crystalline abrasive. Excellent for minor stock removal and burnishing in long run cutting cycles. Available in nine sizes. *The steel alloy outboard motor crankshaft pictured was descaled and smoothed with "Honite" and "Honite" Compound #280 followed by #373.*

B. **"SUPER-HONITE"** – A manufactured chip consisting of a fine-grained, fused aluminum oxide bonded abrasive. Fast cutting and long-wearing – provides a fine, smooth finish on all types of metal. Available in nine sizes. *The hard steel automatic pistol frame was deburred with "Super-Honite" and "Honite" Compound #240; polished with "Super-Honite"and "Honite" Compound #120.*

C. **"HONITE" BRAND CERAMICONES** – A long-wearing porcelain-type, ceramic medium manufactured in precise cone-shaped dimensions. Ideal for deburring, honing, coloring, or burnishing where lodging is a problem. *The yellow brass handle pictured was deflashed and smoothed with "Ceramicones" and "Honite" Compound #300.*

D. **"HONITE" BRAND Z-N TUMBLING SHAPE** – A light-weight medium featuring a new bonding material and extremely fine mesh abrasive. Designed to produce fine surfaces on zinc alloys and other metals prior to plating. Often eliminates the need for costly buffing. *The zinc die-cast locker handle pictured was honed and burnished for plating with "Z-N" 3T Tumbling Shape and a newly developed "Honite": Compound.*

E. **"HONITE" BRAND C-R TUMBLING SHAPE** – A light-weight, fast-cutting medium for use on all metals. Triangular shaped and extremely fracture resistant to prevent lodging. Light weight produces fine, micro-inch finishes without impingement. Available in three sizes. *The aluminum alloy vacuum cleaner head was deburred and prepared for painting with "C-R" 2T Tumbling Shape and "Honite" Compound #240.*

HERE'S HOW you can get the latest information on barrel finishing. VISIT THE "HONITE" BOOTH AT THE NATIONAL METAL EXPOSITION IN PHILADELPHIA OCTOBER 17-21.

COMPOUNDS

There are 14 "Honite" Compounds designed for all types of finishing. Select the compound that fits your needs from these classifications.

1. "HONITE" Abrasive compounds for rapid surface cutting and deburring.
2. "HONITE" Finishing compounds for burnishing, coloring, and light deburring.
3. "HONITE" Cleaning compounds for grease, oil, and scale removal.

Send for FREE booklet

3M COMPANY • 900 Bush Ave., St. Paul 6, Minn.

Gentlemen:
Please send me a copy of your free booklet on "Honite" Barrel Finishing: "There's Gold in Them Thar Barrels."

NAME_____

COMPANY_____

ADDRESS_____

CITY_____ STATE_____

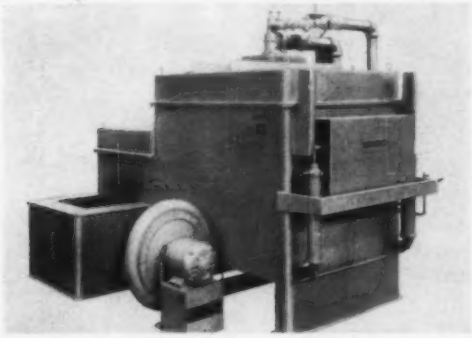
"HONITE" AND "3M" ARE REGISTERED TRADEMARKS OF 3M CO., ST. PAUL 6, MINN.
EXPORT: 99 PARK AVE., NEW YORK 16, CANADA: LONDON, ONTARIO.

MINNESOTA MINING AND MANUFACTURING COMPANY
...WHERE RESEARCH IS THE KEY TO TOMORROW

Circle 1587 on Page 48-B

Double Chamber Melting Furnace

Hevi-Duty Electric Co. announces a line of melting furnaces for use in aluminum sand casting, die casting, or permanent mold plants. The furnaces – either gas, oil, or combination-fuel fired – feature separate firing systems in each chamber to insure rapid melting, and provide the correct holding temperature. Metal quality is improved because moisture is driven off before the molten aluminum reaches the holding chamber. Oxides and dirt are left behind on the sloping dry hearth. Melting rate: 250 to 2000 lb. per hr.; holding capacity: 2000 lb. max.

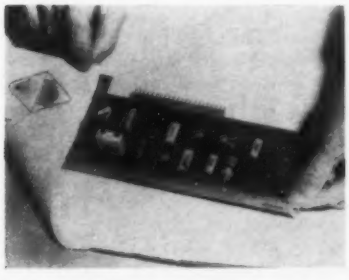


Circle No. 1281 on literature request card

Cleaning and Finishing Equipment

Corrosion Inhibitor Paper

Daubert Chemical Co. manufactures a line of volatile corrosion inhibitor papers for protecting nonferrous metals for several years, even in a very humid or intensely corrosive atmosphere. Actual contact or a tight seal is not required with "Daubrite" wrappers. The protective paper is available in a variety of weights and finishes, in widths up to 60 in., and in sheets or continuous rolls.



Circle No. 1282 on literature request card

Portable Infrared Unit

Fostoria Corp. announces a mobile infrared unit suitable for baking, heating, and drying applications. "Model 96-848" accomodates lamps up to 500 watts per socket, with a total connected load of 24 kw. The unit features gold-plated reflectors for maximum heating efficiency and zoned switching for flexibility of heat output.

For further information circle No. 1283

Electrolytic Process Unit

Hard anodizing, plating, or electrochemical milling operations can be performed with the "Model 500 Allen-Dizer". The unit can also be used for electropolishing, for electrolytic cleaning and etching, and for sulphuric and chromic anodizing. It is ideal for sample preparation, or experimental and short run production. Operating on 120 volts a-c., the rectifier delivers 20 amp. at 100 volts d-c., sufficient for hard anodizing 60 sq. in. of surface. The ¼-ton refrigerator can maintain solutions at any point between 20 and 60° F. *Allen Aircraft Products, Inc.*

For further information circle No. 1284 on literature request card, p. 48B

Welding and Joining Equipment

Flux-Coated Brazing Alloy

Brazing time can be cut by two-thirds if flux-coated alloys are used, it is claimed by *Eutectic Welding Alloys Corp.* "EutecSil 1020 FC" silver-brazing rods offer the advantages of conventional rods while eliminating the need for mixing and applying the flux. The alloy is suitable for ferrous and nonferrous metals and all types of joints – tee, butt, fillet, and lap. The product may be used in joining food-processing equipment.

For further information circle No. 1285

PORTABLE TENSILE TESTER

That Tests Wherever You Take It!

CAPACITIES FROM 2000 TO 40,000 LBS.

Pull tensile tests wherever you may be—in the shop or in the field, in the lab or on the line. Tests flat or round specimens, cast coupons or weld samples. Two simple, compact sizes. Light enough to be carried by two men; rugged enough to stand up under constant moving. Can be mounted on wall or bench according to space limitations.

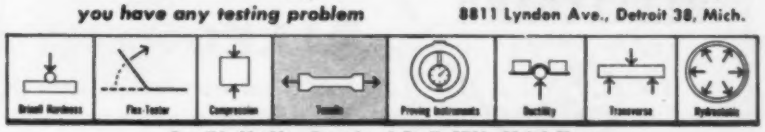
Easily adjustable for specimens up to 2" wide, 12" long. Interchangeable wedge-type jaws readily inserted and adjusted. Load applied hydraulically by manual pump. Capacities up to 40,000 lbs. Cylinder stroke is 2½". Gage is 8½" OD, has maximum indicating hand.

Distributors in most major metalworking areas

Write or call Steel City if you have any testing problem

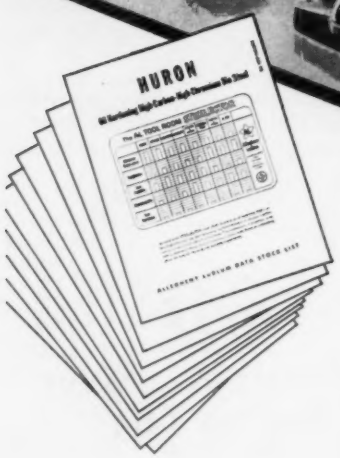
Steel City Testing Machines Inc

8811 Lyndon Ave., Detroit 38, Mich.



See this Machine Operate at Booth 1746—Metal Show
Circle 1588 on Page 48-B

With A-L's Tool Steel Steelector System



You Check Warehouse Availability Right At Your Own Desk

How often have you wished that you could bring the tool steel warehouse right to your desk so that you could see what grades and sizes and shapes are available immediately?

The new Allegheny Ludlum STEELECTOR Program does virtually just that. Special Data Stock Lists (18 of them) for each STEELECTOR Grade specify the complete necessary range of sizes and shapes available that will suit virtually all applications. They also list the working hardness of typical applications, temperatures for hardening, tempering, and annealing, plus other data.

You can count on the availability of STEELECTOR Grades. Mill depot and warehouse stocks have been selected and arranged to take the pressure off your own inventory. With the STEELECTOR Program you can select tool steels almost at a glance and be sure that the steel you have picked is in stock—ready for delivery—before you place your order.

Three STEELECTOR Cards make it easy to choose the proper steel for your application. The cards cover tool room, hot work, and high speed grades. The properties of the STEELECTOR Grades are shown by bar graphs for abrasion resistance, toughness, size stability, machinability, and red hardness. You can pick the grade with the particular combination of properties you need just by glancing at the graphs.

The colorful Tool Steel STEELECTOR Booklet gives complete details of the program, explains the Data Stock Lists, and includes the three STEELECTOR Cards. Ask your Allegheny Ludlum sales representative for your copy, or write: ***Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pennsylvania. Address Dept. MP-10-2.***

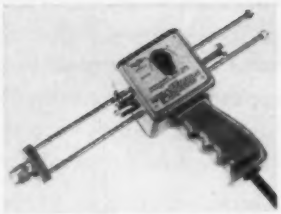
STEELECTOR PROGRAM

ALLEGHENY LUDLUM

Tool Steel warehouse stocks throughout the country

Circle 1589 on Page 48-B

Spot Welding Gun



The "Model H" arc-spot welding gun has an automatic timer control to insure uniformly good welds. The gun will weld 14-gage steel to almost any thickness of mild, galvanized or stainless steel. The weld is made from one side without backup and is very useful for auto-body work and duct work, as well as tank, cabinet, roofing and general sheet metal fabrication. *Bren Weld Corp.*

For further information circle No. 1286 on literature request card, p. 48B

Curved Preforms for Brazing

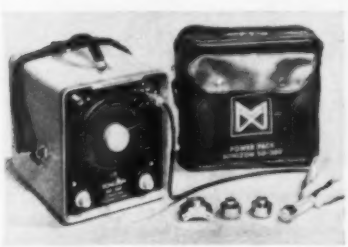
For tubular brazing application, *Lucas-Milhaupt Engineering Co.* is introducing a new concept in preform design. Curved washers and shims made of silver-brazing alloys are custom manufactured to meet individual requirements – such as applications where one tube is "saddle-formed" to fit over another.

For further information circle No. 1287 on literature request card, p. 48B

Inspection and Control Equipment

Ultrasonic Thickness Measuring Device

The "Sonizon SO-300" is a portable, battery-operated instrument for measuring wall thicknessess (0.025 to 2.50 in.) ultrasonically. The transistorized unit has an accuracy of ±1% when calibrated against samples of the material



being measured. It can detect lack of bond in laminated parts and is used in maintenance inspection to find thin sections of structures. Both quartz and the more sensitive lithium sulphate transducers may be employed. *Magnaflux Corp.*

For further information circle No. 1288

Miniature Probe for Spectrometer

Chemical analysis of minute objects 1 mm. to 50 microns in diameter can be made with *General Electric's* minature X-ray probe, which is used with an "XRD-5S" spectrometer. The "Heinrich" probe can identify elements in inclusions, phases and fine grains and can determine the homogeniety of alloys by means of successive readings along the specimen. Two perpendicular motions are controlled by separate micrometer dials covering 13 mm. Areas of interent in the specimen are easily positioned by projecting a light through the collimeter.

For further information circle No. 1289 on literature request card, p. 48B

Gamma Radiography

This large "Gammatron" installation contains 1430 curies of cobalt 60 – equivalent to $40,000,000 worth of radium. The unit handles work previously requiring a 2,000,000 volt X-ray machine costing five times as much. Sections of steel 8 in. thick can be radiographed in 5 min. Exposures requiring hours with an 8-curie source now can be shot in seconds. The cobalt 60 is so intensely radioactive only a small amount (1 cm. in diameter) is necessary. This produces much sharper films. *Radionics Inc.*

For further information circle No. 1290 on literature request card, p. 48B

Crystal Lattice Models

Lattice models built from "do-it-yourself" kits provide excellent three-dimensional visual demonstrations of the crystal structure of matter. Different models can be con-

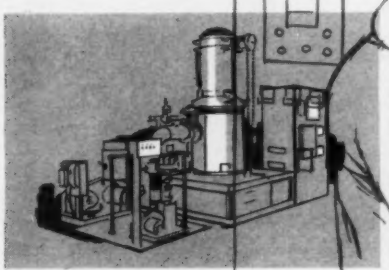
BRINELL
Standard Brinell testing machines. Direct reading, long stroke, and many other modifications available.
Special Models Too!
DUCTILITY
Hydraulically powered 3/16-inch capacity sheet metal testers have up to 30,000-lb. load.
FOR THE BEST BUY DETROIT TESTING MACHINES
TENSILE
Hand-operated portable tensile tester has 4,000 lb. capacity. Hydraulic bench models have up to 40,000-lb. capacity.
Write today for more information.
DETROIT TESTING MACHINE COMPANY
9384 Grinnell Avenue, Detroit 13, Michigan

See us at Booth 1946 at the Metal Show.
Circle 1590 on Page 48-B

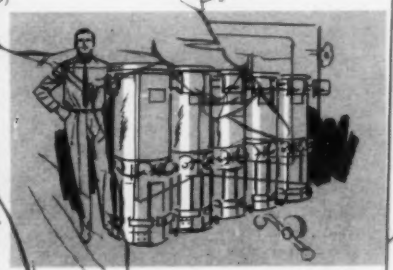
THESE HAYES VACUUM FURNACES WERE DESIGNED FOR INDUSTRIAL HEATING JOBS TOO HOT TO HANDLE BY OTHER FURNACES!

C. I. Hayes is *the pioneer* of vacuum heat treating furnaces. But more important, Hayes still leads today in the development of new, high-temperature, high-vacuum furnaces to meet the needs of Industry. Here are just a few examples of how Hayes solved tough and unusual heat treating problems with Vacu-Master furnaces . . . in each case coordinating furnace design with job requirements.

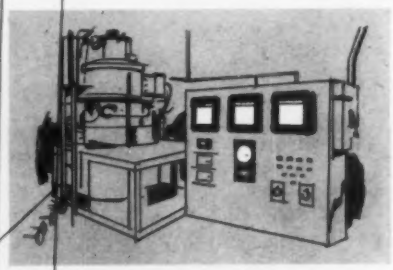
The *versatility* of Hayes Vacu-Master Furnaces has been proved . . . from sintering at temperatures to 4600°F to a wide variety of conventional applications including annealing, brazing, hardening, tempering, sintering and degassing. Perhaps *your* heat treating problem can be solved more efficiently, more economically with a Hayes Vacu-Master furnace.



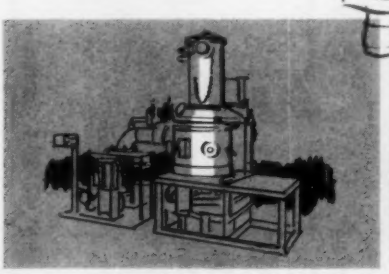
* **In Upper New York State,** this Hayes Vacu-Master operates in the 2200-2300°F Temperature range at sub-micron vacuum for brazing complex stainless steel assemblies. The Hayes cold-wall, fully water-jacketed furnace design provides most efficient cooling of the vacuum chamber . . . and contributes to operating comfort. On one job alone, the Vacu-Master has reduced reject rate four fold.



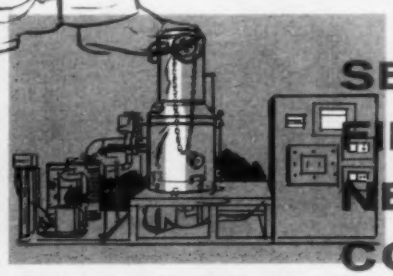
* **The Atomic Energy Division of a Delaware Corporation** utilizes the close temperature control (less than ± 10°F) of this high-speed Hayes Vacu-Master in the 2000°F range for a specialized processing job. Heating chamber of the Vacu-Master has no metal retort. Direct heating means extremely rapid cycling . . . higher quality processing at tremendous savings.



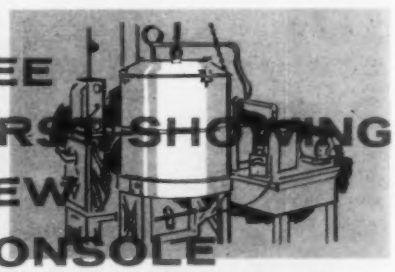
* **Installed in A West Coast Aircraft Plant,** this Hayes Vacu-Master provides automatic programmed control for a complex brazing operation. Temperature control of workpiece is within ±5°F. Vacuum processing plus high speed vacuum cooling insure correct metallurgical structure. Hayes Vacuum Furnaces feature saturable reactor controls to keep element and workload temperatures uniform . . . keep furnace downtime and maintenance to the minimum.



* **At Another New York Plant,** a beryllium-copper hardening job called for a furnace that could operate in the 650°F range within ±3°F — also a furnace capable of handling by simple changes in control settings Ni-Span C (1400°F range), stainless steel annealing, copper brazing, etc. The answer: this versatile Hayes Vacu-Master with wide-range temperature capabilities. The result: quality output without costly rejects.



* **Mid-West Auto Parts Manufacturer** proved the versatility of this Hayes Vacu-Master to handle general heat treating applications in the 600°F to 2200°F temperature ranges. With it, the company has been able to perform economically many difficult annealing, hardening and brazing operations.



SEE FIRST SHOWING NEW CONSOLE VACUUM FURNACE BOOTH 1454 ASM SHOW

* **FIRST Commercial Vacuum Furnaces** sold to industry were designed by Hayes in 1929 for one of the world's largest electrical manufacturing firms. These production-scale vacuum furnaces were used for processing vacuum tube [illegible] and advanced design features included full-jacket cold wall construction . . . way ahead of contemporary equipment! The [illegible] working [illegible]

Complete lab facilities are at your disposal *without cost.* And results are *guaranteed!* Write for Bulletins [illegible] describing Hayes Vacu-Master furnaces.

ELECTRIC CERTAIN CURTAIN FURNACES

*NAMES OF COMPANIES ON REQUEST.

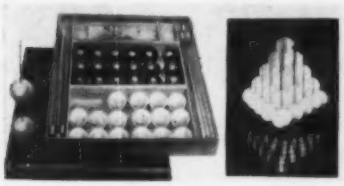
C. I. HAYES, INC.

Established 1905

802 WELLINGTON AVE. • CRANSTON 10, R. I.

Circle 1591 on Page 48-B

structed to show systematic arrangement and crystallographic properties such as periodicity and symmetry. A small model can be enlarged periodically in the direction of the three coordinates to show origin and growth of crystals. The spheres can be closely packed to demonstrate



how the available space is reduced. Kits contain red, white, and green spheres the size of tennis balls, steel needles with magnetic bases, rubber washers for positioning the balls on the needles and a steel baseplate, which can be inclined to show oblique lattice planes from every side. *Arthur S. LaPine and Co.*

Circle No. 1291 on request card

Non-Glare Loupes

Bausch & Lomb is offering a series of "Ray-Ban" tinted magnifying lenses which permit detailed inspection of highly polished parts. Reflected glare – which can obscure

details and cause eye fatique – is eliminated. The lenses, available in several focal lengths with magnifications of 4 × or 7 ×, are used in toolmaking, precision instrument manufacture, and in quality control.

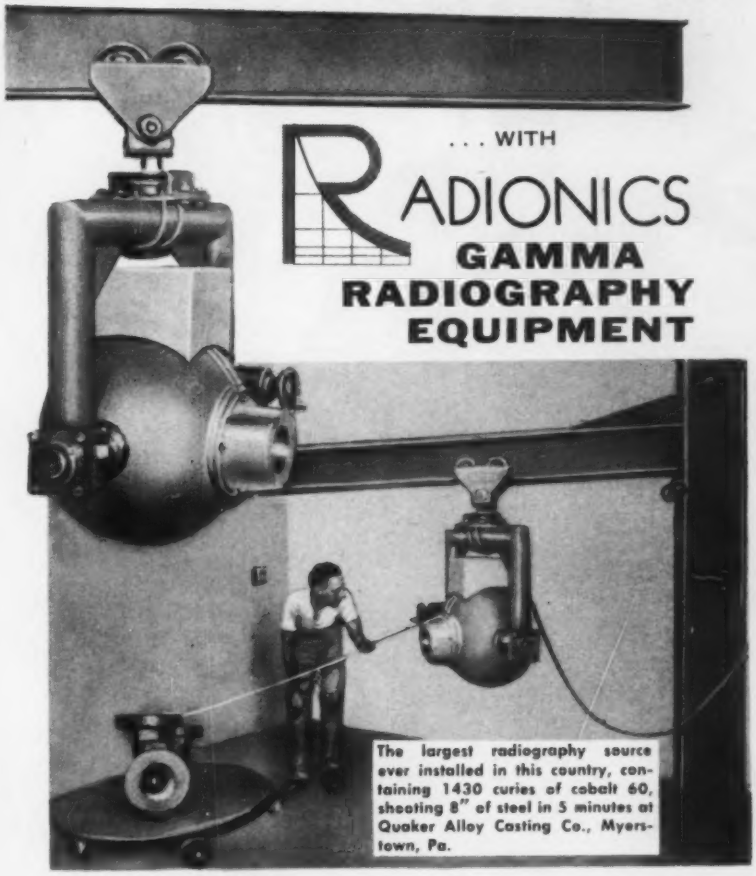
Circle No. 1292 on request card

Universal Tester

The "Plastechon" universal tester can measure tensile, flexural, and compressive properties of all types of materials at rates of loading ranging from 0.2 to 8000 in. per min. Stress-strain curves are obtained automatically by oscilloscope-camera techniques. Features include digital speed selection and remote control operation. *Plas-Tech Equipment Corp.*

Circle No. 1293 on request card

More..... VERSATILITY
More. ECONOMICAL INSPECTION
More..... PENETRATION



. . . WITH
RADIONICS
GAMMA RADIOGRAPHY EQUIPMENT

The largest radiography source ever installed in this country, containing 1430 curies of cobalt 60, shooting 8" of steel in 5 minutes at Quaker Alloy Casting Co., Myerstown, Pa.

METAL SHOW BOOTH #1539

More MODELS — OVER 25 AVAILABLE

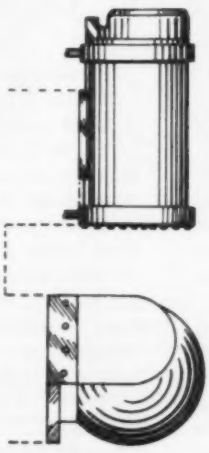
VERSATILITY—Two or more sources in the same machine —beam, internal or panoramic exposures—portability.

SIMPLICITY—No air bottles or cooling water, no external power for most models—negligible maintenance.

QUALITY—Smaller focal spots—more efficient designs —better engineering—more rugged construction.

SAFETY—Position of source shown to nearest half inch with a digital output—less scattered radiation.

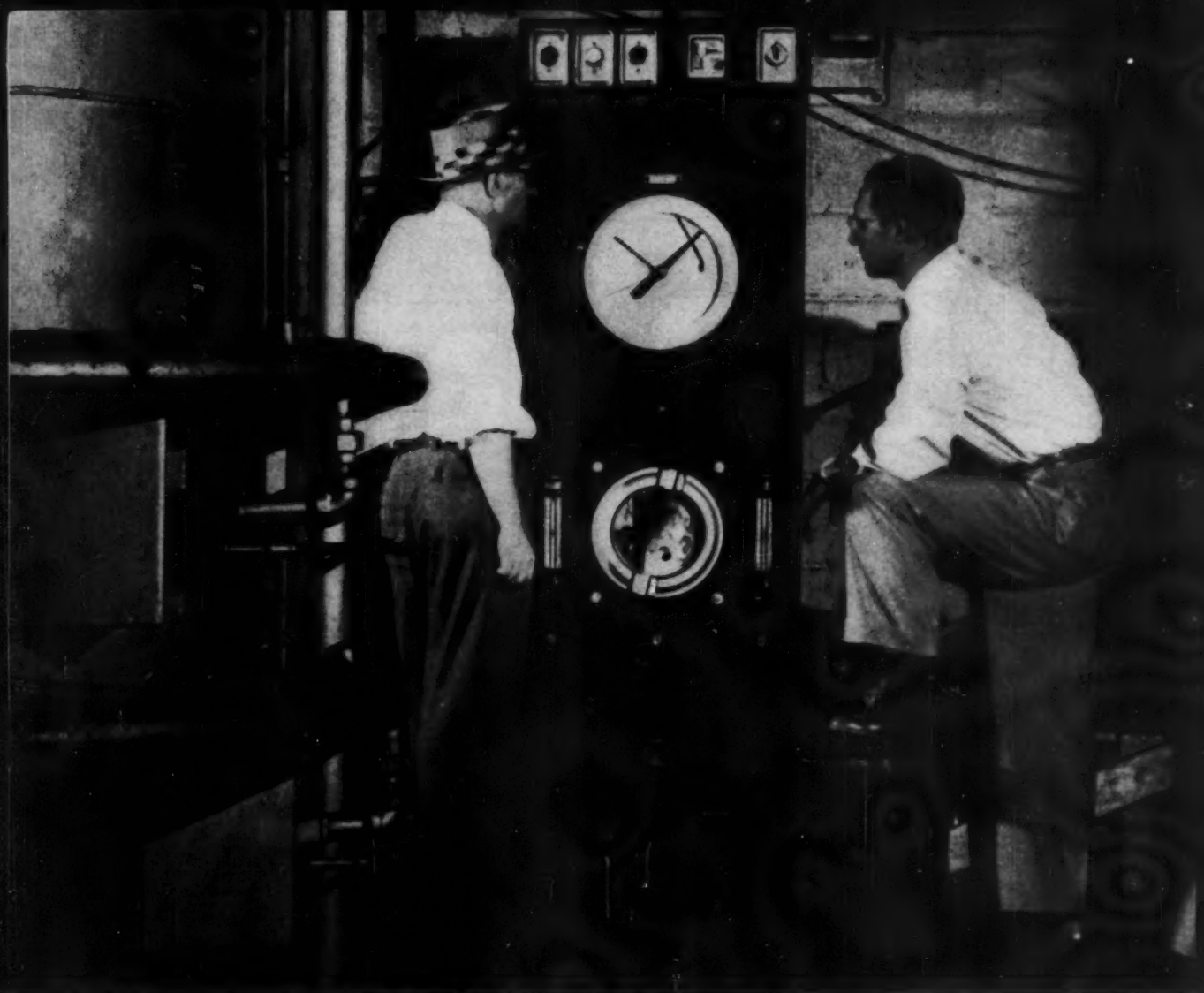
LOWER COST—Save set-ups, cut number of shots required —and the cost is only about 1/5 of that for x-ray.



INTRODUCING the first of a new line of gamma gages for thin or thick metal sections. Accuracy to 0.001" of steel. Speed of response down to 0.01 second. Complete process control systems available.

RADIONICS INCORPORATED
LAFAYETTE & WATER STS., NORRISTOWN, PA.

Circle 1592 on Page 48-B



C. G. Hussey & Company, Pittsburgh, solved a number of copper annealing furnace problems with help from the MSA Instrument Specialist (right), and this Inert Gas Analyzer.

M-S-A® Inert Gas Analyzer eliminates bad heats automatically—assures clear, bright, smooth product

Product uniformity is now continuously and automatically controlled in the C. G. Hussey & Company annealing process. An M-S-A Inert Gas Analyzer with control mechanism has taken over the job.

Before the instrument was installed, the ratio of gases used in the annealing process was maintained by manual controls. The operator had to watch or spot-check analysis instruments. Quality of the resultant atmosphere in the furnace often varied from the range needed for product uniformity.

But now, according to L. A. O'Donnell, superintendent of the heat treating and annealing department: "We haven't had a bad heat since we installed the system. And there's been no major maintenance on the analyzer since it has been in use." In addition to the analyzer on the gas-fired annealing furnace, Hussey & Company also has two others for control of electric furnace atmospheres.

In the Hussey & Company annealing process, the product is heated to annealing temperature while blanketed with an inert gas atmosphere. This atmosphere must be free of oxygen and low in hydrogen to prevent spoiling the product. That's why the M-S-A Inert Gas Analyzer is so vital here. It controls atmosphere to very close limits, records atmosphere quality.

Perhaps this low-cost, low-maintenance instrument has a place in your quality control program. An MSA Instrument Specialist will be pleased to discuss your specific problems with you. Write for information regarding your specific problems of atmosphere analysis and control.

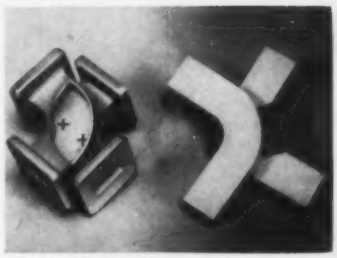
MSA INSTRUMENT DIVISION
MINE SAFETY APPLIANCES COMPANY
Pittsburgh 8, Pennsylvania

Circle 1593 on Page 48-8

Production and Casting Equipment

Castings for Microwave Guides

The *Atlantic Casting and Engineering Corp.* has perfected a combination investment and plaster mold casting technique for producing interior configurations which can be formed by no other means. Standard and special designs for microwave components, in brazable and nonbrazable aluminum alloys are now being cast in production quantities to military specifications.



For further information circle No. 1294

Portable Vacuum Pump

A cart containing a high-speed diffusion pump (either 2, 3, 4, or 6-in. size) can be equipped with a pumping port adapter for coupling to a vacuum furnace, evaporator, environmental chamber, or a laboratory tensile testing furnace. An enclosed refrigeration system for cooling the baffle and pump is featured. This replaces all water cooling and eliminates water inlet and drain lines. The system will provide reduced pressures to 5×10^{-6} mm. Hg without a cold trap and 5×10^{-7} mm. Hg with a liquid nitrogen trap. *High Vacuum Equipment Corp.*

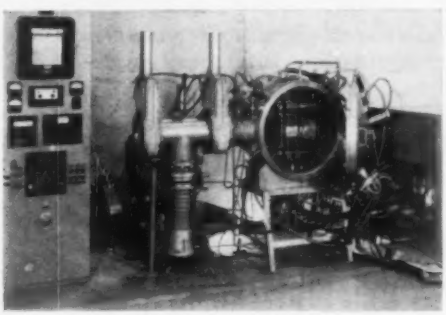
For further information circle No. 1295
on literature request card, p. 48B

Shell Core Machine

"Model SC-100", a 100-lb. capacity shell core machine made by *SPO Incorporated*, can be operated by one man. Cycle time for the production of precision cores is 90 seconds. All operations except the removal of finished cores from the boxes is automatic and individual steps can be varied to meet customer requirements. Features include gravity sand-feed; integral, direct-acting, springless stripping mechanism; automatic timer-controlled blow, dwell, drain-out and cure cycles; gas-fired, thermostatically controlled ovens; and simplified core-box mounting for easy changes. A three-position drain cycle assures complete drain-out of uncured sand.

For further information circle No. 1296
on literature request card, p. 48B

High-Temperature Vacuum Furnace



A tantalum-element resistance furnace with a range to 4200° F. has been developed by *NRC Equipment Corp.* It is used for sintering and heat treating refractory alloy parts and for brazing honeycomb sections. No refractories are present inside the chamber. Inert gas can be provided to increase the cooling rate or replace vacuum during the heating cycle.

Circle No. 1297 on card

Parts, Forms, and Shapes for Design and Application

Pure Beryllium Tubing

Extruded beryllium tubing for nuclear and missile applications is being supplied by *Superior Tube Co.* Beryllium has low density, high rigidity, good oxidation resistance to 1500° F., a low neutron capture cross-section, high thermal conductivity and high heat capacity. The "as extruded" tubing comes in sizes from 0.250 to 2.00 in. O.D. with wall thicknesses of 0.016 in. and heavier. Also supplied as "close-tolerance I.D." tubing.

For further information circle No. 1298
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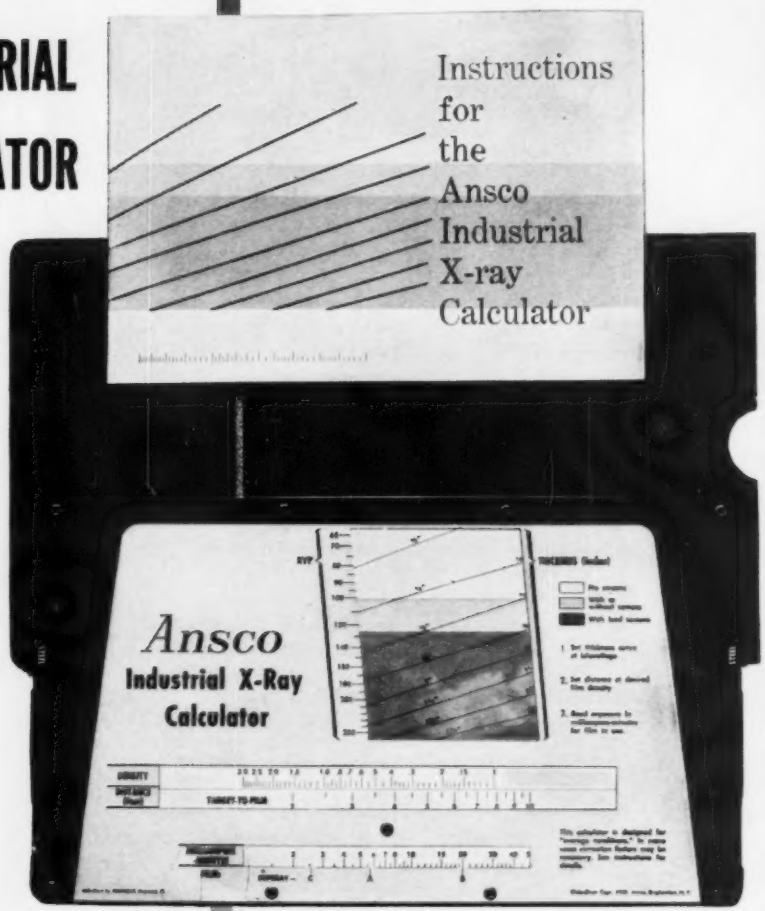
Circle 1594 on Page 48-B

NEW ANSCO INDUSTRIAL X-RAY CALCULATOR SOLVES TECHNIQUE PROBLEMS AT A GLANCE



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Circle 1595 on Page 48-B

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MUTUAL CHROMIC ACID

Sunbeam tops off good construction and design with smart, sturdy chrome plate to win consumer favor for its sparkling line of appliances. Mutual® Chromic Acid and Sunbeam plating technique team up for a brilliant finish.

Mutual Chromic Acid is always 99.75% pure – or better. Its low sulfate content (less than 0.1%) makes it easier for you to control the acid-sulfate ratio of your plating bath. This safeguards against plating difficulties—and expensive rejects!

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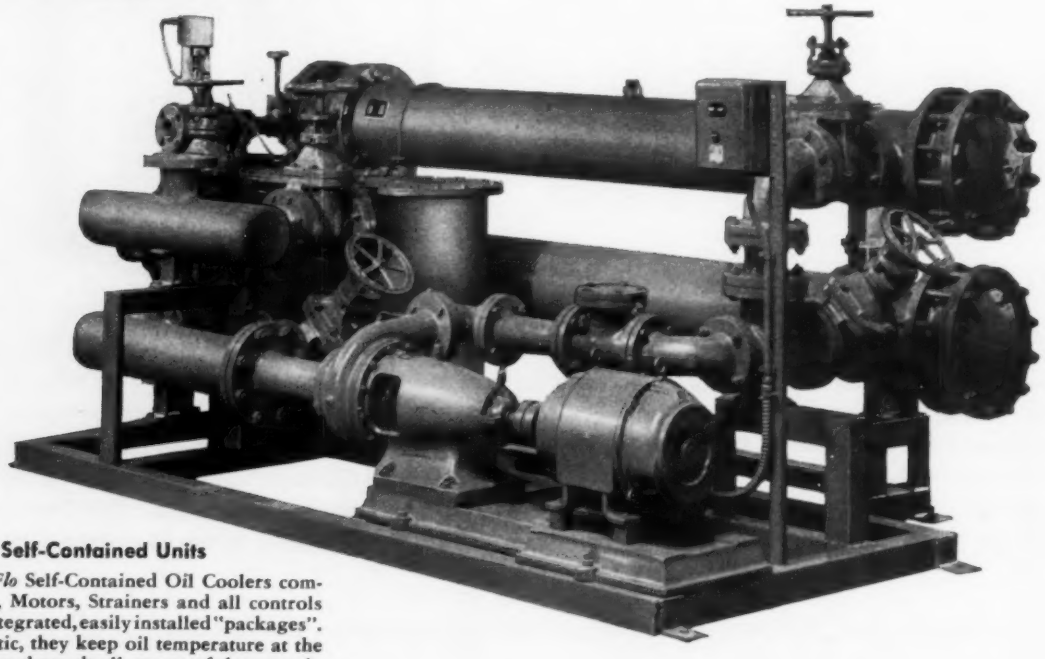
The quenching stage of your heat-treating process is the point which determines . . . (1) the final quality of your product . . . (2) the amount of time and material wasted by below-standard rejects . . . and (3) your ultimate operating costs.

You can protect yourself against needless production losses by installing a B & G Self-Contained *Hydro-Flo* Oil Cooler. This unit will provide the accurate control of conditions in the quench tank which assures *uniform quality* in the finished product.

The generous heat transfer surface in B & G Self-Contained *Hydro-Flo* Oil Coolers provides large capacities in comparatively small, compact units. They are completely factory assembled, ready for immediate installation and operation.

Tell us about your quenching problems—we'll be glad to offer engineering counsel and recommendations.



Completely Self-Contained Units

B&G *Hydro-Flo* Self-Contained Oil Coolers combine Coolers, Motors, Strainers and all controls into single, integrated, easily installed "packages". Fully automatic, they keep oil temperature at the desired degree through all stages of the quench. Your only responsibility is to connect to the quench tank and water lines.

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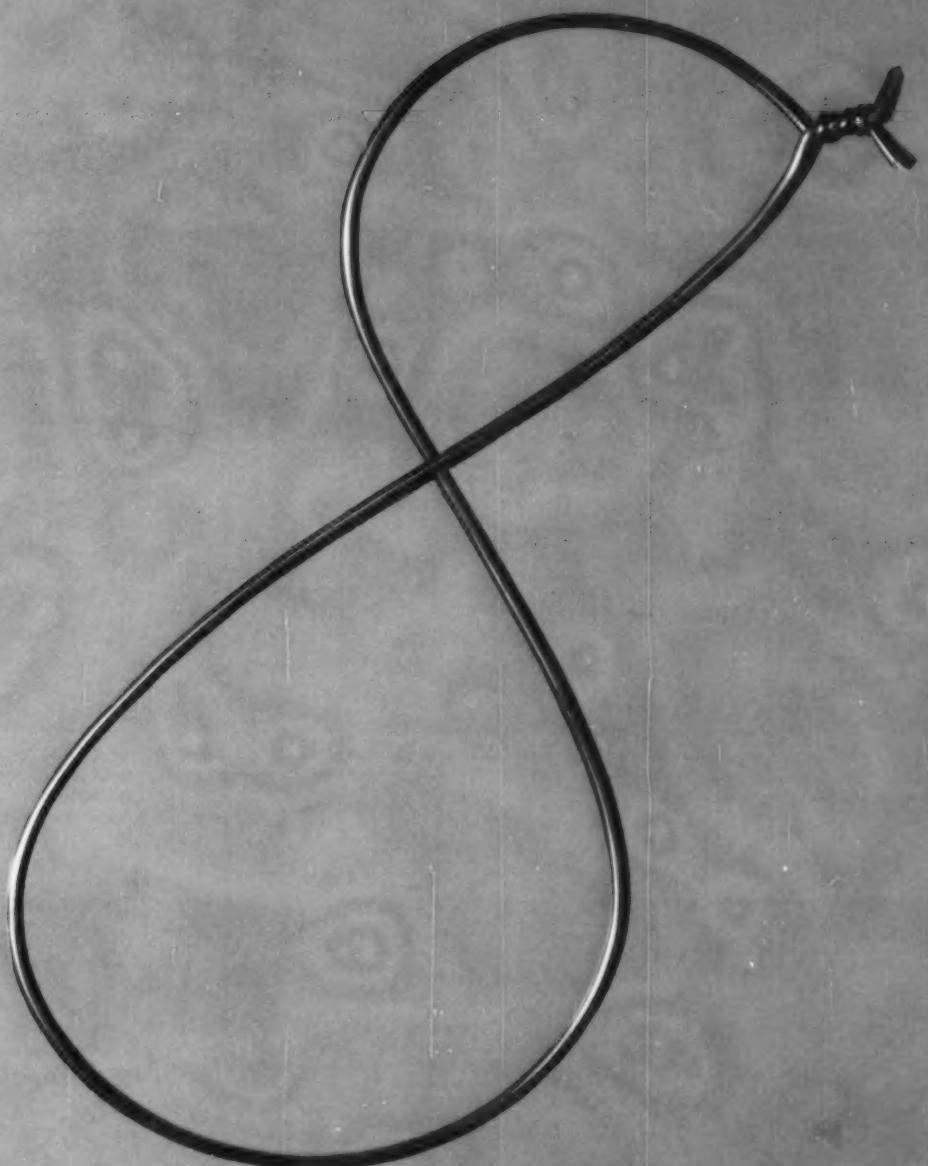

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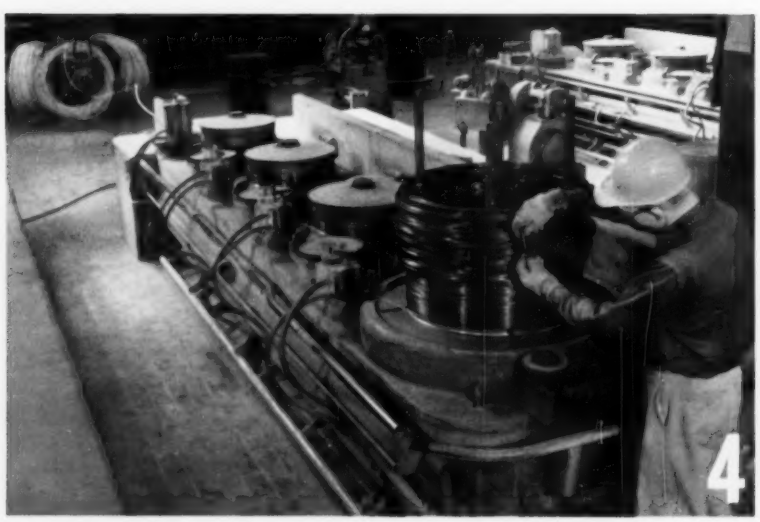
why it pays to specify
American Steel & Wire
for all of your
stainless steel wire needs

good reasons why it pays to specify American Steel

By using modern welding techniques, we can turn out continuous coil weights as heavy as 500 pounds to suit your particular needs. Heavier coil weights reduce down time on your machines, speed handling of material.

The latest in controlled annealing methods enable us to produce uniform properties in stainless wire that assure consistent performance on your equipment and in your product.



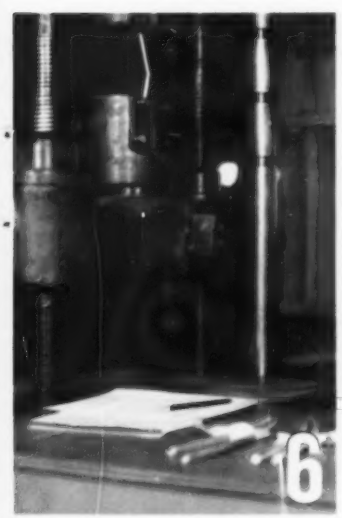
To insure the gage of your stainless is consistent from end to end, it's checked constantly during the continuous drawing process. ASW's wide range of modern, precision drawing machines can turn out everything you need in type, size and finish.

After drawing, the wire is again inspected to make certain that the gage and finish are exactly as specified.

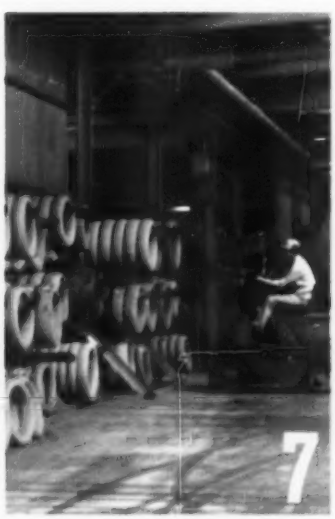
This mark tells you a product is made of modern, dependable Steel.

& Wire for all of your stainless steel wire needs

Up-to-date salt and acid bath techniques and equipment guarantee the smooth, clean wire surface so important to the finished quality of your product. After cleaning, coatings such as this electrolytic copper coating are often applied to make your job of fabrication easier.



During processing and at finished size, our stainless wire is tested for tensile strength and other properties to make sure it meets specifications. Such tight control insures quality.



To insure supply and fast delivery, we stock 300 to 400 tons of cold heading stainless wire in addition to a heavy tonnage of other stainless steel wire items at all times.

8 Our stainless steel wire service is second to none. In addition to our regular salesmen, we have special Stainless Steel representatives in your area who have both engineering and mill backgrounds. They know metals, they know production. Their assistance can be invaluable to you in solving the really tough ones. Call your nearest ASW Sales Office today. If you like, we'll have a man out to see you at your convenience. Or if you prefer, write American Steel & Wire, Dept. 0390, 614 Superior Avenue, N.W., Cleveland 13, Ohio.

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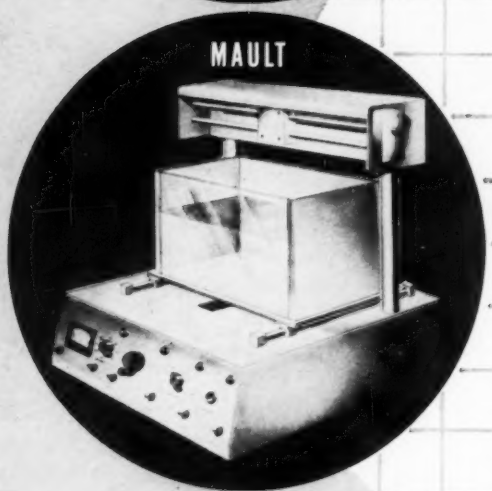

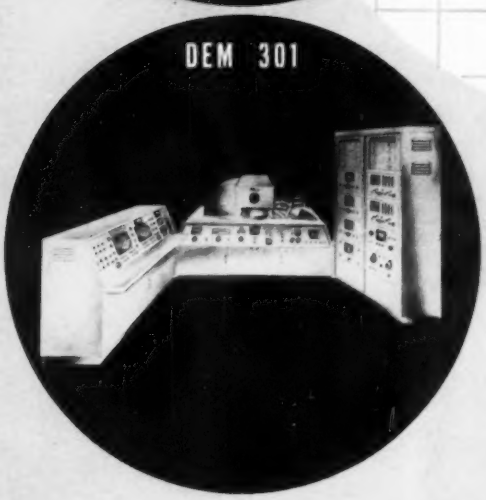

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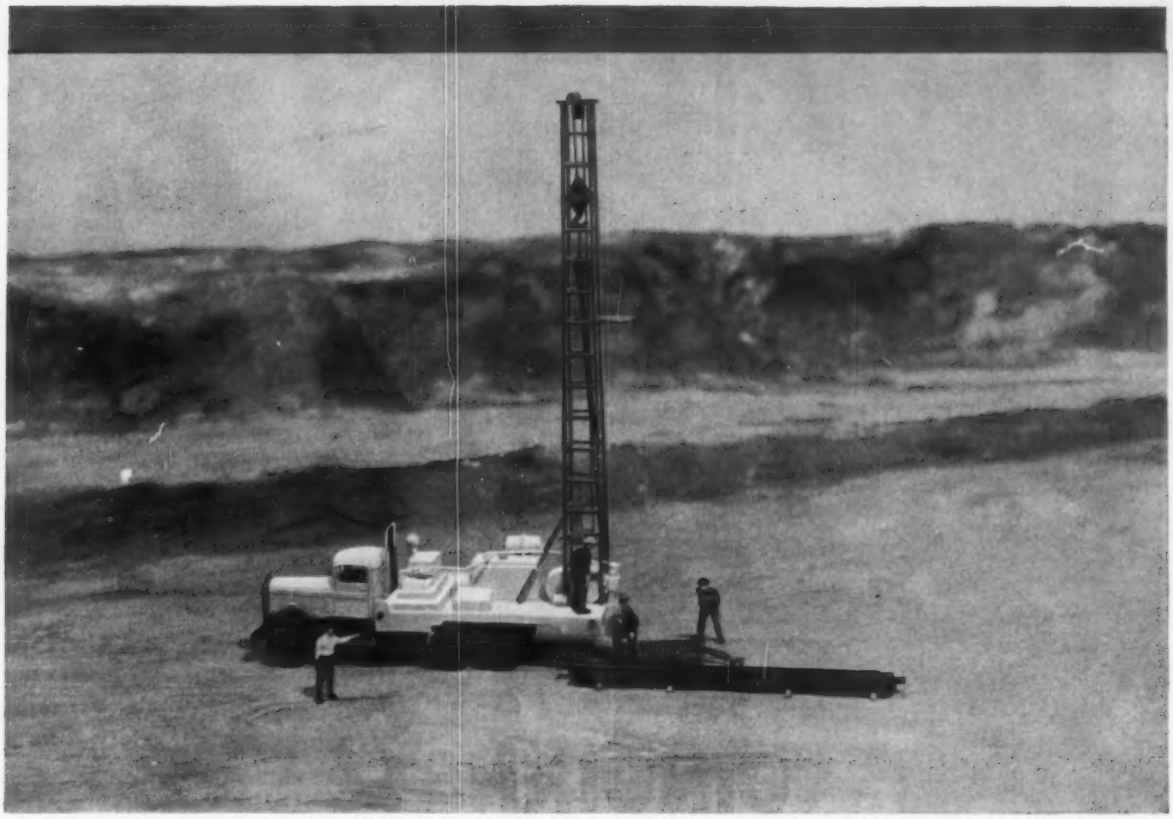


Down-to-earth reasons for using Custom Quality OHIO Tubing

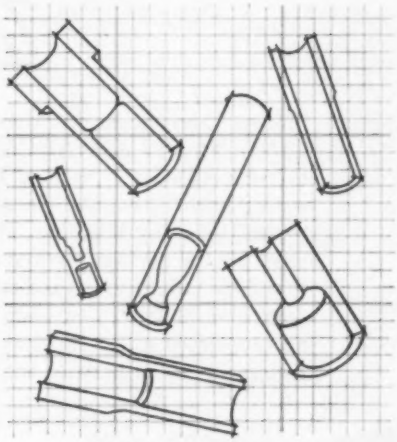
As in rotary drilling, which uses steel tubing internally upset by Ohio Seamless, greater strength and lighter weight may be important in your product.

So before selecting a tubing source consider these important facts. OHIO Tubing is always the exact tubing you need for your product because OHIO Tubing is CUSTOM MADE for your product. Your order is manufactured to your own specifications to produce steel tubing especially for your application — the precise grade, analysis, size, shape, special anneal and tolerances best suited to your needs.

Ohio Seamless Tube produces both seamless and electric welded steel tubing — is prepared to form many finished or semi-finished tubular parts to your designs.

To get the most from your next steel tubing order, use Custom Made OHIO Tubing. Contact your nearest Ohio Seamless representative, or send part drawings to the plant at Shelby, Ohio — Birthplace of the Seamless Steel Tube Industry in America. A-9061A

Model illustrated built to 3.5 mm scale.



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Travels to the job

Shown above is another example of CINCINNATI ADVANCED HEAT ENGINEERING . . . a new Inductron® 400 cycle, 30KW, Motor Generator Heating-Stress Relieving Machine. This unit is being used for the preheating and stress relieving of welded piping. Designed to be transported from one job site to another, heating can be accomplished up to 200 feet away from the generator—in otherwise inaccessible places

Circle 1600 on Page 48-B

—using small diameter cables and wrap-around or clamp-on coils. The heating cycle is automatically programmed.

As builders of a complete line of Flamatic® flame heating and Inductron motor generator and radio frequency induction heating machines, CINCINNATI is ready to serve you with detailed engineering calculations and the selection of tooling and heating equipment to solve your heat processing needs. Let the benefits of CINCINNATI ADVANCED HEAT ENGINEERING work for you. Call in a Meta-Dynamics Division field engineer.

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1300. "Vest Pocket Guide to Better Welds"

This revised edition contains 80 pages of arc welding information on causes and cures of common welding troubles, five essentials for proper welding, and

electrode selection. Also included are cost-saving hints, safety precautions, welding symbols, types of joints, power sources, and definitions of welding terms. *Hobart Brothers Co.*

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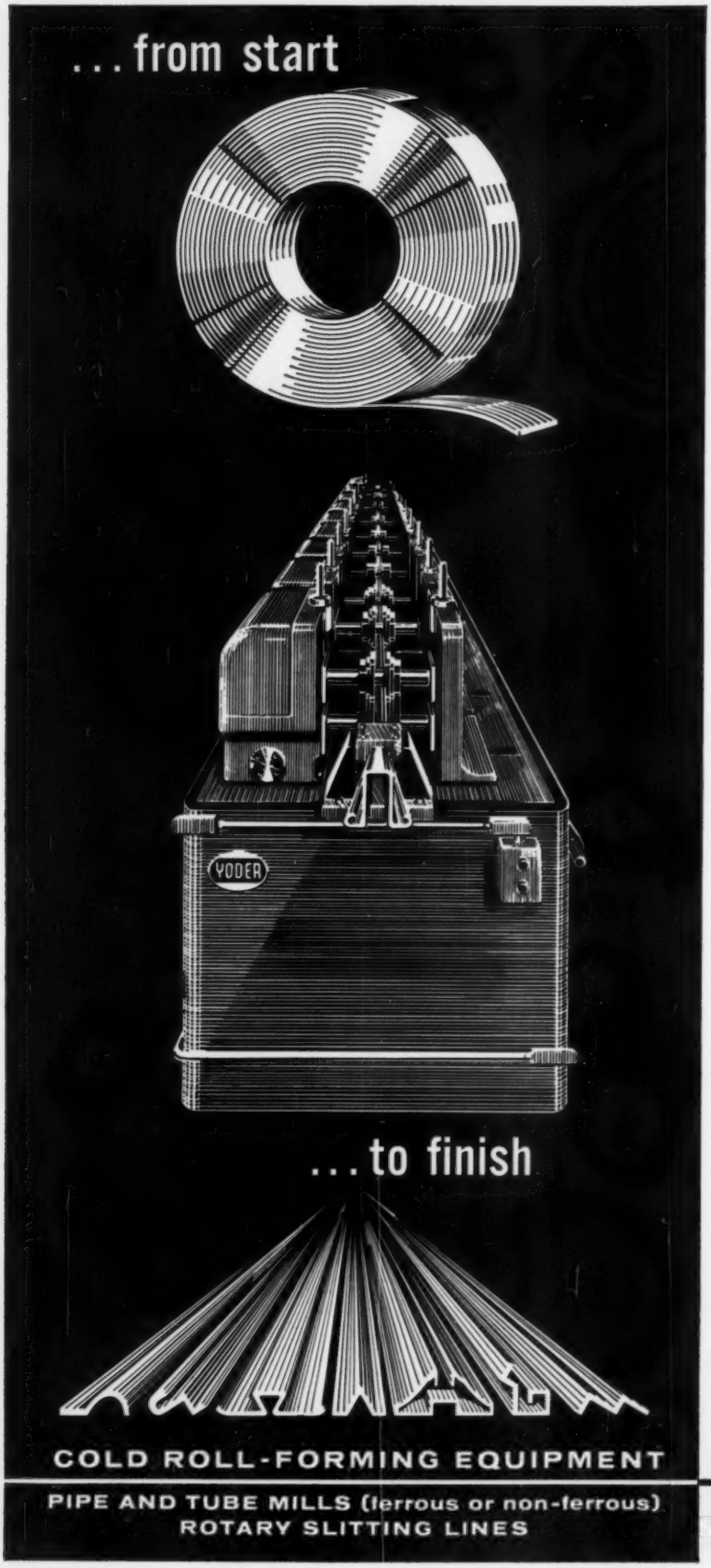
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Circle 1601 on Page 48-B

pressed and sintered in a hydrogen furnace. More information on product and applications is available from *General Electric Co.*

1331. Superalloy Forgings

Wyman-Gordon will supply information on forgings made of Waspaloy, René 41, Astroloy, Udimet 500, M-252, and titanium alloys.

1332. Refractories

Carborundum has published "Super-Refractories" booklet, full of useful data on unusual refractories, including silicon carbide with high heat conductivity for furnace muffles.

1333. Beryllium Oxide

BeO is an excellent reflector and moderator of neutrons, is inert to chemical attack, and has good thermal conductivity. Melting point is 4658°F. *Brush Beryllium* has detailed information on "Uox" sintered BeO components.

1334. Cobalt-Base Alloys

Haynes Stellite Co. has data on cobalt-base alloys for tough applications. Available as castings, forgings, sheet and bar stock, or fabricated parts.

1335. Ta, W, Mo, Cb

Fansteel Metallurgical Corp. has a "Warehouse Price and Stock List" on refractory metals and alloys — Cb, Ta, W, Mo, and others.

1336. Silicon Carbide

Norton Co. will send details on "Crystolon 63", a nitride-bonded silicon carbide for refractory applications, such as aluminum reduction cell linings.

1337. Graphite Products

Information from *National Carbon Co.* on graphite products for aluminum extrusion operations. Guides, runout table covers, and cooling racks will not char . . . will not scratch and stain the extrusion.

1338. Alloy for 2300°F. Service

Information from *Electro-Alloys Div.* on composition and properties of "Supertherm", a superior alloy for static, centrifugal, and shell-molded castings operating in the 1800-2300°F. range.

1339. Stainless Alloys

International Nickel Co. will send "First Steps Toward Solving Specific Corrosion Problems" . . . simplified forms you can use to state your problem.

1340. High-Temperature Alloys

48-page booklet on *Haynes Stellite Co.* plant facilities, including complete vacuum melting equipment for producing high-temperature alloys.

1341. Cemented Carbides

Allegheny Ludlum offers 12-p. pamphlet on "Carmet" cemented carbides for wear-resistance. Contains charts, case histories, and selection data.

1342. High-Alloy Castings

International Nickel Co. has published a 64-p. booklet "Heat Resistant Castings, Corrosion Resistant Castings . . . Their Engineering Properties and Applications."

Nuclear Materials

1343. Nuclear Graphite

National Carbon Co. offers information on graphite for nuclear applications—excellent structural material, corrosion and thermal shock resistant, high-moderating qualities, easily fabricated.

Tool Materials

1344. Impacter Process

Practical information with examples of successful mechanized forging operations is included in brochure "Automatic Production of Forgings in Closed Dies." *Chambersburg Engineering Co.*

1345. Colloidal Graphite

"Colloidal Dispersions For Use in Metal Casting", Bulletin 425, discusses dispersions available for coating permanent molds, die cavities, and steel and cast-iron chills. *Acheson Colloids Co.*

1346. Chemical Milling

Brochure from *Eastman Kodak Co.* discusses "Metal Etch Resist", a photo-sensitive material which allows close-limit accuracy and speeds up chem-milling operations.

1347. Die Steels

"Lo-Air" tool and die steels cut production costs. 12-p. brochure from *Universal-Cyclops* on applications and properties of these steels.

1348. "Moly" Lubricant

Free sample tube of "Molycote G" lubricant. Eliminates galling and seizing of all bearing metal combinations. *Alpha-Molykote Corp.*

1349. Tube Mills

64-p. illustrated *Yoder Co.* Tube Mill book gives complete information on pipe and tube mills. Ferrous or nonferrous tube from 5/16 to 26 in. diameter.

1350. Toolsteels

Ziv Steel and Wire Co. has literature on "Hargus" oil hardening toolsteel for blanking, forming, and drawing dies.

1351. Diamond Grit

16-p. brochure from *Engelhard Hanovia, Inc.*, presents information on "SND" grinding abrasives. Selected natural diamonds for improved grinding performance in resinoid-bonded wheels.

1352. Lubrication System

Information on automatic lubricating system which continuously circulates clean oil through machine bearings at controlled rates. *Bijur Lubricating Corp.*

1353. Power Supply Units

Anocut Engineering Co. has published Bulletin 126 on electrolytic supply units for machining and other metal-removal operations.

1354. Rolling Oil

Baker/Gubbins Co. will send literature on "Compound No. 717", a rolling oil which reduces power requirements and eliminates cleaning prior to annealing.

1355. Press Brakes

Steelweld Mechanical Press Brakes has issued Catalog 2023B, 50 pages, covering line of mechanical press brakes—160 to 1250 tons.

1356. Wheel Dressers

Catalog discusses tangential angle wheel dressers for tool and cutter grinders and cylindrical grinders. *L. Newman Co.*

1357. Hydraulic Presses

Verson Allsteel Press Co. offers 24-p. catalog covering mechanical and hydraulic presses and press brakes, hydraulic shears, tooling, and special machinery.

Industrial Heating

1358. Immersion Heating

Data Sheet M11 on *Dean Products, Inc.* "Panelcoil" for immersion heating or cooling. Panelcoil can be formed to fit almost any space and can be assembled in special banks to give high capacity per cu. ft.

1359. Thermostat Control

Bulletin 122 discusses "Model S-15" thermostat which has 8 standard ranges up to 1150°F. This miniature unit is a differential expansion-type control. *Burling Instrument Co.*

1360. Industrial Ovens

Young Brothers Co. has published Bulletin 157 which describes accurate, dependable, low cost heat treating operations with their ovens. Batch and conveyor types up to 1000°F.

1361. Induction Melting

Inductotherm's Bulletin 70 gives the advantages of induction melting, including time and cost savings, increased service life, and melting flexibility.

1362. Gas Burners

Catalog from *Chas. A. Hones, Inc.* presents line of "Buzzer" burners and furnaces for melting and heat treating—including atmospheric pot furnace for cyanide, salt bath, and lead hardening.

1363. Micro-Optical Pyrometer

Accurately measures targets as small as 0.001 in. diameter or remote objects. Range: 1300 to 5800°F. Reproducibility: 2°C. Catalog 95 from *Pyrometer Instrument Co., Inc.*

1364. Gas Furnaces

American Gas Furnace Co. Catalog 607 covers bell retort, tube, muffle, and continuous furnaces plus burners, blowpipes, and blowers.

1365. Industrial Furnaces

If you want to heat (melt, forge, braze, sinter, or treat) ferrous, nonferrous, or exotic metals, in air or a protective atmosphere, *Surface Combustion Corp.* can supply your needs. Bulletin SC-175.

1366. Temperature Measurement

6-p. data sheet from *Leeds & Northrup* describes line of optical and standard pyrometers, including their construction and operation. A lens is available for sighting on glowing objects as small as 0.003 in.

1367. Air-Draw Furnace

Hevi-Duty Electric Co. offers Bulletin 660 on gas-fired or electric "Rotair" furnaces for tempering, drying, or annealing. Operating range: 1700°F. or 1350°F.

1368. Quenching Oil

"Voluta" oil from *Shell Oil Co.* is a high-speed quenching oil that is ideal in static and circulating quench systems. It remains stable up to 180°F.

1369. Induction Heating Equipment

8-p. brochure presents data on complete line of induction heating equipment for billet heating, heat treating, annealing, joining, melting, and sintering. *Ajax Magnethermic Corp.*

1370. Thermocouple Fittings

Conax Corp.'s 32-p. Catalog 1890 illustrates line of thermocouple fittings, pressure sealing glands, and thermocouple accessories. Specifications, applications, and prices are listed.

1371. Quenching Oils

Leaflet No. 61 from *Sun Oil Co.* contains data on "Sunquench 1070" fast-quench oil and "Sunquench 1021" a hot-oil type of quenching medium. Characteristics and benefits obtained from their use are presented.

1372. Atmosphere Furnace

Sunbeam Equipment Corp. has published Bulletin SEC-9 on automatic "Casemaster" furnace for carburizing, carbonitriding, carbon restoration, normalizing, annealing, and hardening. Range: up to 1850°F.

1373. Elevator Furnaces

Bulletin GED-4092 gives data on electric elevator furnaces for increased production, higher quality, and greater

To request any item listed, circle appropriate number on Reply Card, p. 48B

THESE ARE EXTRAORDINARY FLUXES

The correct selection of flux can offer unexpected help in speeding and simplifying production, minimizing rejects and lowering costs in low temperature silver brazing operations. The advantages to be gained by "selective fluxing" are *sufficiently important to warrant careful, thorough study!*

Silvaloy offers the most advanced flux developments in this specialized field. Here, is *a complete line of fluxes* . . . each providing outstanding performance, enabling you to select the correct flux for every possible low temperature brazing operation. The extra efficiency of Silvaloy "Selective Fluxing" is being proved daily on the brazing production lines of the country's leading manufacturers.

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Silvaloy fluxes are packaged in 65-lb. and 30-lb. drums, 5-lb. wide mouth jars (5 to a carton), 1-lb. and ½-lb. jars. The wide opening of the 5-lb. package makes it a most practical, time saving dispenser that also enables the operator to make use of every bit of flux in the jar.

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Circle 1602 on Page 48-B

economy in stress relieving and annealing heavy batch loads. *General Electric.*

1374. Thermistor Bolometers

"Servotherm" infrared radiation detectors are uniformly sensitive throughout entire visible, near-infrared, and far-infrared spectrum. Bulletin TB 1300-1 from *Servo Corp. of America.*

1375. Oil for Quenching

Comprehensive literature on "Super-Quench" from *Gulf Oil Corp.* In quenching thin-sectioned parts, costly straightening is eliminated when dual-action quench oil is used.

1376. Protective Atmospheres

20-p. Bulletin 591 describes line of furnaces and equipment for protective atmospheres—exothermic and endothermic generators, ammonia dissociators, N_2 and H_2 generators, dryers, scrubbers. *Electric Furnace Co.*

1377. Flame Detector

Bulletin 95-2776 describes "Ultra-Vision" flame detector, which responds only to the ultraviolet energy given off by the flame. *Minneapolis-Honeywell.*

1378. Gas Generators

Rolock's endothermic gas generator has complete reversibility and features self-cleaning of catalyst beds. Literature available.

1379. Hump Furnace

Bulletin GEO-3990 describes muffle-less mesh-belt hump furnace for bright brazing, heat treating, or sintering stainless steel — to 2200°F. *General Electric Co.*

1380. Inspirator Burner

E. W. Bliss Co. has information on "HP220 Series" fast-acting inspirator burners for ovens, kilns, foundry melting furnaces, and other heat-processing units.

1381. Pusher Furnaces

Ipsen Industries, Inc. has data on pusher furnaces for production carburizing . . . chain discharge . . . enclosed charging mechanism . . . ceramic "flame-busters". Bulletin P59.

1382. Annealing Stainless

Drever Co. has Bulletin 81 on furnaces for annealing stainless steel strip. Complete lines including descaling units are offered.

1383. Oils for Quenching

"Quenchtex" oils give uniform hardening in the piece with improved grain structure and no darkening of the metal. A longer bath-life is obtained. Folder from *Texaco.*

1384. Pyrometers

Bulletin 4257 describes *Alnor Instrument Co.'s* "Pyrocon", which will read any surface temperature in 3 sec. Eight models with ranges from 0—300°F to 0—2000°F.

1385. Process Development

Solve your heat treating problems in *C. I. Hayes* laboratory — on production equipment. Bulletin 1961 gives full details of heat treating facilities in the laboratory.

1386. Heating Elements

For precise, economical electrical heating, use "Globar" silicon carbide heating elements. Range: 1400 to 2800°F. *Carborundum Co.*

1387. Atmosphere Analyzer

Complete, accurate, automatic analysis of furnace atmospheres — O_2, CO, CO_2, CH_4 — is possible with *Perkin-Elmer Corp.'s* rugged instrument.

1388. Custom Furnaces

Pacific Scientific Co. has published a catalog on custom designed furnaces, such as a dual-range gantry furnace which heat treats aluminum and steel alloys.

1389. Melting Furnace

Bulletin 594 describes gas-fired, double chamber, dry-hearth furnace for melting and holding aluminum for die casting operations. *Hevi-Duty Electric Co.*

1390. Electric Furnaces

"Pereco" electric furnaces for heat treating, melting, research, sintering, and ceramic applications. Bulletin 570 from *Pereny Equipment Co.*

1391. Automatic Austempering

Bulletin 700 from *Ajax Electric Co.* on "Cataract Quench" which meets practically any TTT curve requirement with precision.

1392. Laboratory Furnaces

Information on complete range of tubular, resistance wound, shunt-type furnaces for many uses up to 2600°F. *Marshall Products Co.*

1393. Temperature Crayons

"Tempilstik", a simple and accurate means of determining temperature. Free samples of "Tempil" pellets. *Tempil Corp.*

1394. Radiant Tubes

General Alloys Co. has data on wrought-cast radiant tubes. Also "Lindberg" tubes, all-wrought tubes, and all-cast tubes.

1395. Quench-Oil Coolers

Catalog and Selection Manual from *Bell and Gossett Co.* on "Hydro-Flo" self-contained quench-oil coolers and oil quenching systems.

1396. Induction Heating

56-p. catalog from *Induction Heating Corp.* on "Ther-monic" induction heating equipment — electronic, low-frequency, or motor-generator types.

1397. "Heat-Proof" Coating

"C-R" coatings protect a wide range of metals against oxidation, corrosion, scaling, and gas absorption at temperatures as high as 2100°F. during heat processing operations. *Marshal Co.*

1398. Furnace Equipment

Lindberg Engineering Co. has information on complete line of heat processing equipment, as well as a 500 cfm. "Hyen" atmosphere generator.

1399. Low-Temperature Cabinets

Revco Inc. offers folder "Selecting a Low-Temperature Cabinet". Units provide temperatures to —140°F., controllable within 1°F.

1400. Open-Coil Process

Lee Wilson Engineering Co. has information on open coil gas alloying. Better steels are produced with up to $40 a ton savings.

1401. Sub-Zero Probe

Bulletin 52-16 from *Thermo Electric Co.* on sub-zero "Ceramo-Couple" which eliminates condensation when measuring low temperatures to —320°F.

1402. Pyrometric Equipment

Bristol Co. offers electronic potentiometers (including miniature models and millivoltmeter and radiation-type pyrometers for every kind of heating equipment. Write for complete data.

1403. Annealing Furnaces

Annealing of small parts can be done at low cost in an automatic rotary furnace (600 to 1800°F. operating range). Details from *American Gas Furnace Co.*

1404. Metal-Mesh Belts

130-p. reference manual published by *Cambridge Wire Cloth Co.* tells of metal-mesh belt applications for heat processing. Labor costs, handling and production

Circle appropriate number on Reply Card, p. 48B

NEW

KENTRALL HARDNESS TESTERS are Motorized

By removing major test loads automatically, the new motorized Kentralls reduce operator error, increase reproducibility of test results, and raise the productive capacity of the machine—for the same price as hand operated testers.

The motorized Kentralls are available in Combination Testers which provide both Regular and Superficial Rockwell Hardness Testing in a single machine. For those applications that do not require the additional range, Kentrall also makes single purpose testers for either Regular or Superficial testing alone.

For complete information write for Bulletin CRS 60

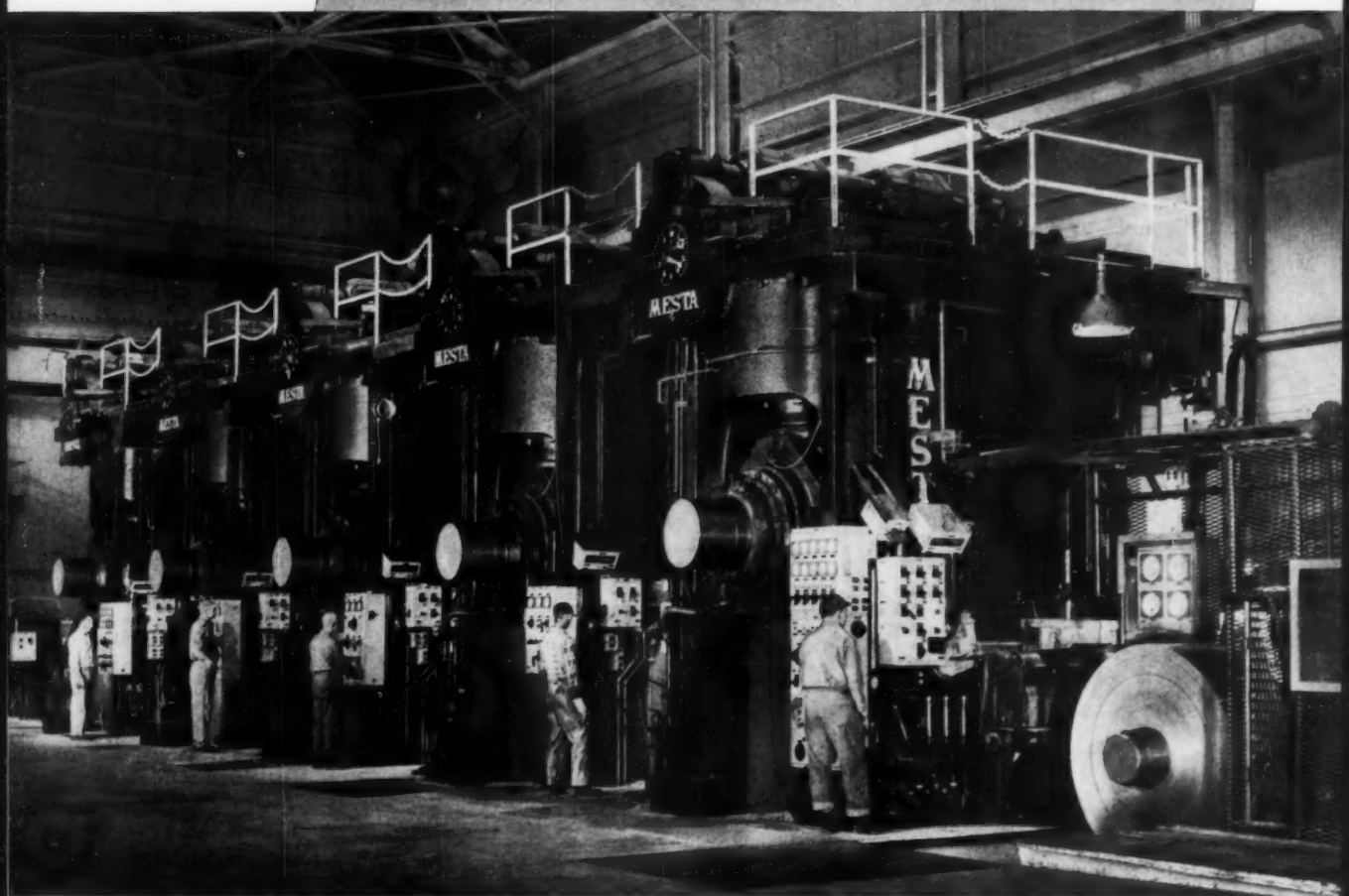
KENTRALL **THE TORSION BALANCE COMPANY**

Main Office and Factory: Clifton, New Jersey
Sales Offices: Chicago, San Francisco

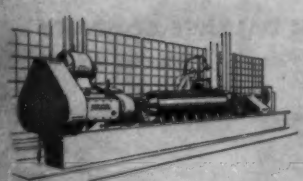
TB163

Circle 1603 on Page 48-B

MESTA Cold Mills



MESTA 48" Four-High, Five-Stand Tandem Cold Mill
Rolling Strip Steel for Tin Plate in Coils



Designers and Builders of Complete Steel Plants

MESTA MACHINE COMPANY

PITTSBURGH, PENNSYLVANIA

Circle 1604 on Page 48-B

time are cut.

1405. Annealing Equipment

Bulletin SC182 from *Surface Combustion Corp.* on "Power Convection" furnaces for annealing foil uniformly and at low cost.

1406. Temperature Controls

Engineering data from *Wheelco Instruments Div.* on "Capacitrols", the ultimate in control instrument flexibility, with "Electronic Link" no-contact control.

1407. Vacuum Crucibles

Literature on vacuum crucibles, button furnaces, ingot molds, hot topping units, and a description of *Zak Machine Works, Inc.* facilities.

1408. Thermocouple Alloys

Hoskins Mfg. Co. will send data on "Cromel-Alumel" thermocouple alloys, guaranteed to register true temperature-emf values over the range from −300°F. to +2300°F.

1409. Radiant Tubes

Information from *Pressed Steel Co.* on all-sheet radiant tubes. Longer life . . . less cost . . . uniform gas flow.

1410. Furnace Blowers

Catalog 126B contains complete specifications on industrial blowers, in standard capacities of ½ to 1000 hp., up to 20,000 cfm., and 4 oz. to 10 lb. pressure. *Spencer Turbine Co.*

1411. Conveyer Furnace

Bulletin HT-53 from *Carl Meyer Corp.* describes continuous conveyor-type aluminum billet heating furnaces (2500 lb./hr.).Temperature uniformity in the furnace is guaranteed.

1412. Environmental Test Unit

Cincinnati Sub Zero Products has information on "hi-lo" test chamber for service from +250°F. to −120°F. Thermal capacity: 400 Btu./hr. at −120F°.

1413. Metal Belts

From needle bearings to engine blocks you can depend on metal process belts to carry the load—up to 2100°F. "High Temperature Catalog" from *Ashworth Bros., Inc.*

1414. Recirculating Ovens

12-p. Bulletin 71TH describes complete line of high-temperature, recirculating, gravity, and forced-convection ovens. *Trent, Inc.*

1415. Tantalum Thermowells

Fansteel Metallurgical Corp. has published leaflet on thermowells and bulb sheaths for protecting recording instruments in corrosive reagents.

1416. Radiation Pyrometer

Bailey Meter Co. will send 4-p. Product Specification E51-4 on a-c. radiation pyrometer for measurements to 4000°F.

1417. Heating Elements

Heatrex, Inc. has released "Folio 500" on electrical heating elements for immersion, cartridge, strip, tubular, and switch heater applications.

1418. Protective Coating

Stop scaling, carburizing, and decarburizing with "C-R" heat-proof coatings. Information from *Markal Co.*

1419. Furnace Elements

Leaflet from *Pacific Scientific Co.* discusses advantages in using "Radiant Plate" elements in high-temperature furnace designs.

1420. Infrared Analyzer

Leeds and Northrup will send Folder N91620 on infrared analyzer equipment for automatic control of heat treating atmospheres. Can be calibrated for CO, CO_2 or CH_4.

1421. Induction Hardening

Bulletin from *Ohio Crankshaft Co.* describes "Tocco" induction hardening applications. Pump shafts that are machined and hardened in one operation . . . no additional handling is required.

1422. Industrial Furnaces

Harper Electric Furnace Co. has published pamphlet on electric and gas furnaces—box, pusher, mesh-belt hump or "straight-through", roller hearth, bell, elevator, or pit.

1423. Thermocouples

Catalog G100-4 contains details on "Megopak" small-diameter, flexible thermocouples. High-speed response . . . 150,000 standard combinations of materials and fittings. *Honeywell.*

1424. Heat Treating Furnaces

The *Electric Furnace Co.* will send 12-p. bulletin on electrically heated, continuous chain-belt conveyor furnaces for scale-free hardening, carbonitriding and other heat treating operations.

Cleaning and Finishing

1425. Electrostatic Hand Gun

"Model 10" ionic, electrostatic hand gun applies metallic and non-metallic paints and coatings economically to complex shapes and structures, such as wire fences, artwork and outdoor furniture. *Ionic Electrostatic Corp.*

1426. Continuous Coating

Bulletin RW500 from *J. O. Ross Engineering Div.* describes continuous coating line for strip aluminum, steel, or tin plate.

1427. Metal Abrasives

Cleveland Metal Abrasive Co. has published catalog discussing the merits of "Realsteel" abrasives.

1428. Solvent Degreasing

Detrex Chemical Industries will send you a copy of Dr. C. E. Kircher's informative paper, "Solvent Degreasing—What Every User Should Know".

1429. Sample of Plating

Send *R. O. Hull & Co.* a typical part for plating and specify barrel or still-plated, cadmium or zinc, with or without chromate conversion dip. No obligation.

1430. Flux Addition Agent

Information from *Westinghouse* on "Wes-X 501", a flux addition agent for zinc galvanizing or hot tinning. It retards oxidation and promotes uniform film coverage.

1431. Abrasive Media

Pangborn offers Bulletin 350 on fine crystalline fused aluminum oxide chips for all vibratory and barrel finishing machines.

1432. Ultrasonic Cleaning

Bulletin 60-1 "How to Clean Ultrasonically With Self Tuning". Autosonic tuners eliminate operator training and monitoring. *Powertron Ultrasonic Corp.*

1433. Phosphate Coating

Booklet from *Turco Products, Inc.* on "Paintite", a phosphate coating. Phosphating Reference Chart included.

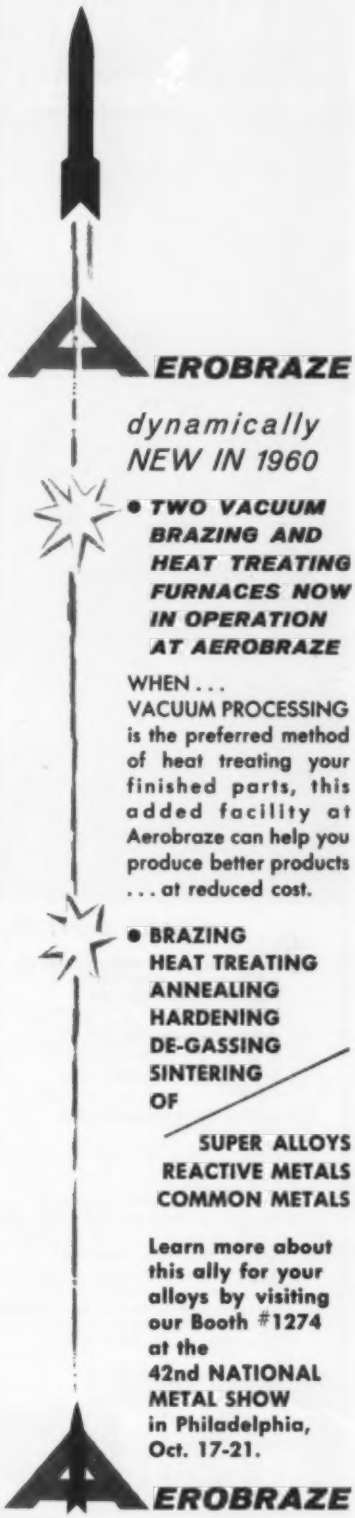
1434. Airless Spray

Nordson Corp. will send information on "Hot Airless System" paint spraying. Heat and pressure provide maximum control and reduce paint waste.

1435. Rubberized Abrasive

Cratex Mfg. Co. has published an Industrial Catalog on rubberized abrasives for micro-deburring, smoothing, cleaning and polishing.

Circle appropriate number on Reply Card, p. 48B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NEW IN 1960
• TWO VACUUM BRAZING AND HEAT TREATING FURNACES NOW IN OPERATION AT AEROBRAZE
WHEN . . .
VACUUM PROCESSING is the preferred method of heat treating your finished parts, this added facility at Aerobraze can help you produce better products . . . at reduced cost.
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Learn more about this ally for your alloys by visiting our Booth #1274 at the 42nd NATIONAL METAL SHOW in Philadelphia, Oct. 17-21.
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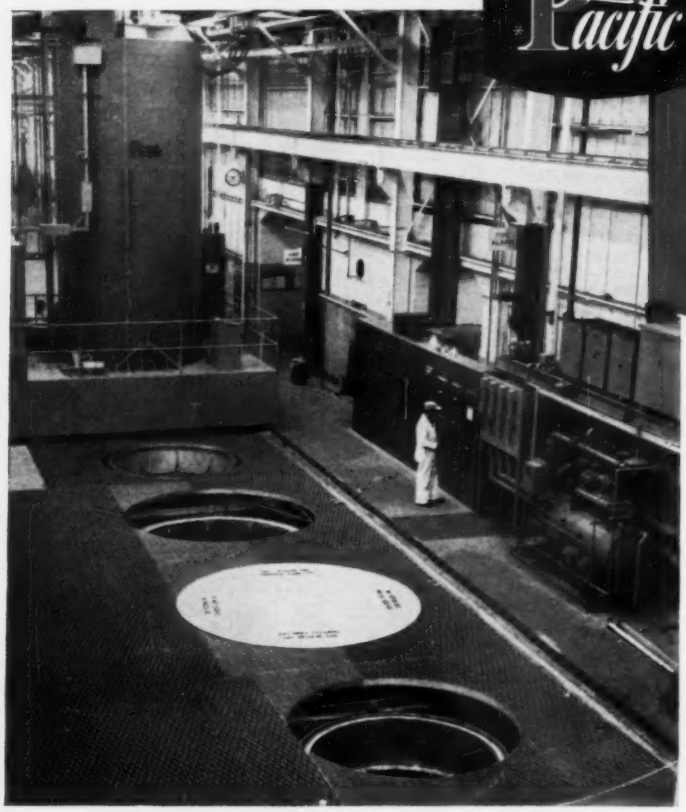
Circle 1605 on Page 48-B

For rapid-production heat-treating of large missile components...

DOUGLAS AIRCRAFT CHOSE Pacific TO DESIGN AND BUILD THIS

GANTRY QUENCH VERTICAL DRAW FURNACE



ANOTHER PACIFIC FIRST! Gliding over two draw furnaces, an oil quench tank and an atmosphere tank, this big Pacific gantry furnace has been in successful operation at Douglas Aircraft Company's Torrance, California plant for over a year.

Large as it is, operation is virtually automatic requiring only one operator. Relatively delicate missile bodies are quickly removed from furnace to furnace to tank under carefully controlled conditions of atmosphere and temperature. Heated parts are never exposed to air as pneumatically operated sleeves make it possible to join quench tanks and draw furnaces to the gantry furnace.

The installation has been so successful that it will be more than doubled in size in the near future with the addition of another gantry furnace riding on the same track and more draw furnaces and quench tanks.

SIGNIFICANT FURNACE FACTS

- Installation includes gantry furnace, draw furnace, oil quench tank, atmosphere quench tank, and loading bay.
- Working dimensions are 74 in. dia. by 19 ft.
- Gantry furnace temperature range to 2000°F.
- Rated at 400 kw divided into four zones of control.
- Pit type draw furnace temperature range to 1350°F., rated at 200 kw.
- Heated with 80 nickel 20 chrome wire.
- Endothermic and exothermic atmospheres provided.
- Heated parts may be transferred from gantry to tanks without exposing to air.
- Entire installation controlled by one operator riding on gantry.

PHOTO COURTESY DOUGLAS AIRCRAFT COMPANY

LARGE OR SMALL, STANDARD OR SPECIALLY TAILORED...

Whether your problem is heat treating large missile parts as at Douglas, brazing honeycomb, or heat treating tiny electronic parts, Pacific can supply the one best furnace for your every requirement!

On each job, Pacific engineers make an intense and thorough creative study of the product to be heat-treated, and the materials processing and handling requirements. This is done to reduce and simplify processing methods. Net result proved by many installations, is that Pacific Furnaces handle materials faster—easier—simpler—more practically. This approach to furnace design plus Pacific's extensive experience in all types and sizes of furnaces will give you your one best solution to your heat-treating problem.

Whatever your requirements—a Pacific field engineer will be glad to discuss it with you. For full information on a modern Pacific Scientific Furnace engineered to your needs—call or write today!

Free! NEW 8 PAGE COLOR BULLETIN ON PACIFIC BRAZING FURNACES. Features complete line from laboratory furnaces to complex automatic giants.

ALSO.. BIG 12 PAGE COLOR CATALOG ON PACIFIC HEAT TREATING EQUIPMENT. Standard, modified and specially designed furnaces are illustrated and described for most every requirement. Write today!

Pacific ®TRADE MARK

GAS OR ELECTRIC INDUSTRIAL HEAT TREATING EQUIPMENT

Creative Development and Manufacturing in Furnace Design

PACIFIC SCIENTIFIC COMPANY

LOS ANGELES
SAN FRANCISCO
SEATTLE
PORTLAND, OREGON
ARLINGTON, TEXAS
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DENVER

PACIFIC SCIENTIFIC COMPANY, P.O. Box 22019, Los Angeles 22, Calif.

☐ Please send me information on custom designed furnaces. ☐ Please send me your FREE Brazing Catalog. ☐ Please send me a copy of your new catalog and full information on Pacific Heat Treating Equipment.

Name_____

Company_____

Address_____

City_____ Zone____ State_____

Circle 1606 on Page 48-S

1436. Barrel Finishing

Booklet on "Honite" barrel finishing compounds. Abrasive compounds for rapid surface cutting. Finishing compounds for burnishing, coloring, and light deburring. *Minnesota Mining and Manufacturing Co.*

1437. Zinc Phosphate

Bulletin F8979 discusses "CrysCoat" zinc phosphate coatings on steel for lasting corrosion protection under paint. *Oakite Products, Inc.*

1438. Degreasing Solvent

36-p. bulletin explains how you get more and better vapor degreasing with "Nialk Trichlor". Equipment, cycles, operating procedures, stabilizers, solvent recovery, trouble shooting included. *Hooker Chemical Corp.*

1439. Abrasive Shot

The *Globe Steel Abrasive Co.* will tell you about how you can benefit from the exact type of "Malleabrasive" shot or grit to do your particular job best.

1440. Selective Plating

Brochure offered by *Sifco Metachemical, Inc.* on the "Dalic" process for production and repair plating without using immersion tanks.

1441. Metal Finishing Supplies

Data files on *Allied Research Products* line of metal finishing products and processes for corrosion protection, paint base and decorative finishing.

1442. Shot and Grit

"Controlled-T" shot gives high-speed cutting action without rapid breakdown. Savings up to 50% on consumption. Data available from *National Metal Abrasives.*

1443. Red Smut Preventative

Literature on "Ebonol Additive S" is available from *Enthone, Inc.* Added to steel blackening baths it prevents the formation of red smut.

1444. Ultrasonic Generator

National Ultrasonic Corp. will send product data sheet covering "Model G310" 1000-watt generator for cleaning and degreasing operations.

1445. Polishing Mills

8-p. catalog describes polishing mills for finishing metal sheets, plates and coils. *Acme Mfg. Co.*

1446. Barrel Finishing

Tumb-L-Matic, Inc. has data sheet on "LS Type" barrel tumbling equipment for finishing metal and plastic parts by the dry process.

1447. Phosphate Coating

Kelite Corp. offers leaflets on "Kotekleen" detergent and "Keykote 25" powdered phosphate composition which provides superior paint bonding.

1448. Alkaline Cleaner

Information available from *Turco Products, Inc.* on "Surj", an alkaline platers' cleaner that eliminates the hazardous acid pickling process.

Welding and Joining

1450. Filler Wire

Cannon-Muskegon will furnish details on vacuum-melted filler wire for high-quality welds. Size: 1/32 to ⅛ in. diam.

1451. Power Supplies

Glenn Pacific Power Supply Corp. offers literature on "Variable Slope" constant voltage power supplies for all consumable electrode welding processes.

1452. Silver Brazing

Bulletin 20 from *Handy & Harman* gives a good picture of silver brazing and its benefits . . . includes details on alloys, heating methods, joint design, and production techniques.

1453. Flame Plating

Up to 40 times longer wear for metal parts coated with *Linde's* "flame-plating" process. Tungsten carbide surface provides resistance to abrasion, galling, erosion, fretting and corrosion.

Inspection and Control

1455. Fatigue Testing

Riehle Testing Machines will send Bulletin RF1059 on "Riehle-Los" fatigue testing machines, which combine static and dynamic testing capabilities.

1456. Spectroscopy Equipment

Radio Corp. of America has complete details on horizontal goniometer, which performs six functions by adding accessories.

1457. Recorder—Controller

Catalog 08-101-A from *Daystrom Inc.* furnishes complete information on line of "Weston" recorder-controllers and other instruments for industry.

1458. Mass Spectrometer

Bulletin 21130-X1 presents data on "Model 21-130" laboratory mass spectrometer, a medium-priced instrument with performance equal to that of larger units — over a reduced mass range. *Consolidated Electrodynamics.*

1459. Hardness Testers

Catalog RT58 gives information on superficial testers, as well as a full line of Rockwell hardness testers. *Wilson Mechanical Instruments Div.*

1460. Conductivity Meter

Magnaflux Corp. will provide data on "Magnatest FM-110," a fully portable, all-transistorized, battery-powered electrical conductivity meter for sorting nonmagnetic metals.

1461. Tensile Testing

Bulletin T859 from *Steel City Testing Machines, Inc.* describes line of tensile testing machines, including portable models in capacities from 2000 to 40,000 lb.

1462. Cut-off Machine

The "Metal Digest," Vol. 2, No. 2, describes "Model 1114 AB Cutter," a wet abrasive cut-off machine for laboratory work on stock up to ½ in. *Buehler Ltd.*

1463. Industrial X-Ray Unit

"Baltograph 300" penetrates up to 4 in. of steel, permits 360° radiography, can be coned down to a single beam, and can inspect thin aluminum. *Westinghouse.*

1464. Reference List

A 20-p. x-ray literature list of 376 papers from 1930 to 1960 will be sent by *Phillips Electronic Instruments.*

1465. Microscopes

Catalog 2G on metallographs and universal camera microscope for direct observation, photography, and measurement of opaque and transparent specimens. *Unitron Instrument Div.*

1466. Record Charts

Bulletin Y1906 from *Bristol Co.* on special charts for recording instruments. Up to 32 in. wide in strip charts; 12 in. diameter for round charts.

1467. Optical Pyrometer

Instrument Development Laboratories, Inc. has pamphlet on "Pyro-Eye," a two-color optical pyrometer which provides automatic measurement and control in the range 1400 to 4500°F.

1468. Force Measurement

Baldwin-Lima-Hamilton has data on strain gages and force measurement systems, including large load cell to measure 1,500,000-lb. rocket thrust.

Circle appropriate number on Reply Card, p. 48B

MEASURE TEMPERATURES ACCURATELY FAST with

PYRO OPTICAL PYROMETER

Instantly measures temperatures of minute spots, fast moving objects, smallest streams. Stock ranges from 1400° F to 7500° F.

Send for free catalog No. 85.

and

the universal

PYRO SURFACE PYROMETER

Quick-acting, precise, with easy-to-read 4¾" dial. Single and double ranges — 0°-300°F to 0°-1500°F for surface and subsurface temperatures. Also sub-zero and special ranges.

Send for free catalog No. 168.

PYROMETER INSTRUMENT CO., INC.

BERGENFIELD 8, NEW JERSEY

Circle 1607 on Page 48-B

NEW MIXER

Get set to topple some traditions in fluid-mixing ease and economy

You won't have to lubricate it for five years.

You can't overload the gear drive.

It comes with a chemical plant motor as *standard,* at no extra cost.

You don't need three hands to remove the shaft.

And it mixes fluids like no portable mixer you've ever seen. Delivers up to 45% more fluid flow in gear-drive models. Higher impeller head in direct-drive models. Actually lets you handle many mixing jobs with a *smaller* mixer drawing *less power.*

That's just a sampling of the new LIGHTNIN Portable Mixer. It's ready —in sizes from ⅛ to 3 hp. And the price is right.

Your LIGHTNIN Mixer representative will be glad to show you why you can use it to mix fluids better—and at lower cost—than ever before. You'll find him listed in Thomas' Register of American Manufacturers and in the yellow pages of your telephone directory. Call him today. Or write us for descriptive Bulletin B-520.

SHOCK OVERLOADS can't damage the mixer drive. In gear-drive models, GripSpring assembly between gear and drive shaft lets gear slip if overloaded more than 50%. It's a safety feature you never could get before in a portable mixer.

IN FIXED MOUNTINGS, TOO. Get the same all-new advantages in permanent-mounting LIGHTNIN Mixers for open and closed tanks. A complete line, sized from ¼ to 3 hp. For details on these, send for Bulletin B-521.

"Lightnin® Mixers"

MIXCO fluid mixing specialists

MIXING EQUIPMENT Co., Inc., 171-K Mt. Read Blvd., Rochester 3, N.Y.

In Canada: Greey Mixing Equipment, Ltd., 100 Miranda Ave., Toronto 19, Ont.

Circle 1608 on Page 48-B

1469. Direct-Reading Spectrometer

Bulletin SC-1 from *Baird-Atomic* on direct-reading spectrometer to save time, eliminate waste, and improve quality control.

1470. Metallographic Equipment

Catalog E232 from *Bausch & Lomb* describes line of metallographic equipment. Fast, dependable analyses can save you time and material.

1471. Portable Hardness Tester

Details available from *Barber-Colman Co.* on a portable hardness tester for brass, copper, aluminum, other soft metals, and plastics.

1472. Gamma Radiography

Budd Co. has prepared a brochure on "Iriditron" units, designed for remote handling of iridium 192 (30 curies of iridium 192 equals a 260 kv. X-ray machine).

1473. Strain Gages

Budd Instruments Div. has information on "Tatnall MetalFilm 101" strain gages. No integral leads; ultra-thin (0.0015 in.).

1474. Photomicrographic Cameras

Brochure SB682 describes line of *American Optical Co.* "Spencer" photomicrographic cameras. Permanent micrographs are ready for your files in just 60 sec.

1475. Fatigue Testing

Bulletin RF1059 on hydraulically-actuated fatigue testing machines (12,000 to 300,000 lb.) which can be used to perform dynamic tests as well as conventional static tests. Frequency range: 125 to 1000 cpm.; also 5 to 100 cpm. *Riehle Testing Machines.*

1476. Diffractometer

Picker X-Ray Corp. will give you full story on X-ray diffraction and fluorescence analysis equipment for easier, faster, more accurate work.

1477. Hardness Testing

Illustrated reference book on hardness testing available from *Clark Instrument, Inc.,* makers of "guaranteed accurate" Rockwell testers.

1478. Carbon Determinator

16-p. catalog illustrates both sulphur and carbon determinators. Equipment accurately determines carbon content in 2 min. *Harry W. Dietert Co.*

1479. Emission Gage

General Electronics X-Ray Emission Gage is an "on-line" laboratory for quality control. "XEG" performs continuous analysis of solids, liquids, slurries, powder, sheet, and wire during production.

1480. Borescopes

Borescope catalog from *National Electric Instrument Div.* describes "Fontar" inspection equipment for holes as small as 0.100 in. I.D.

1481. X-Ray Film

Flyer from *DuPont* on X-ray film combining fine-grain emulsion and "Cronar" polyester photographic film base for exceptional optical clarity.

1482. "The Analyzer"

Quarterly magazine from *Beckman* features case histories of actual applications involving their products and technical papers on developments in the area of instrumentation.

1483. Rockwell Testers

Flyer from *Advance Industries, Inc.* announces a line of portable hardness testers which embody an entirely new loading principle.

1484. "Photocord"

Quarterly publication by *Photovolt Corp.* covers news of their products, such as reflection meters, densitometers, and the "Thrombograph."

Production and Casting

1487. CO_2 Generators
Bulletin CD-260 from *Louis DeMarkus Corp.* describes CO_2 manufacturing system. Foundries can produce CO_2 at a fraction of purchased cost and also eliminate handling of cylinders.

1488. Liquid Metals Handling
Liquid Metals, Inc. has information on electrodynamic pumps and flowmeters, circulation and recovery systems, dry boxes, purifiers, and industrial furnaces.

1489. Manganese Additions
Bulletin 201 discusses benefits of pure "Electromanganese" additions—such as minimizing the harmful effects of carbon, silicon, and other impurities on deep drawing steels. *Foote Mineral Co.*

1490. Fabricated Parts
R. C. Mahon Co. has literature on "steel-weld" fabrication, including mechanical and structural parts which were formerly cast in steel or aluminum.

1491. Gas Generator
Gas Atmospheres, Inc. has information on a single-base, completely packaged gas generator for minimum volume gas users. Other models from 50 to 50,000 cfh.

1492. Vacuum Impregnation
16-p. brochure from *F. J. Stokes Corp.* discusses advantages of the process—such as increasing the strength and reliability of aluminum, magnesium, brass and bronze castings.

1507. Pure Nickel
Foote Mineral Co. offers illustrated brochure on 99.9% pure nickel in the form of briquets or powder.

Parts, Forms, Shapes

1509. Steel Fasteners
Republic Steel Corp. has published literature describing "Nylok" self-locking fasteners. A nylon insert forces mating threads together for maximum holding power under vibrating or shock-loading conditions.

1510. Precision Tubing
Catalog 5 describes platinum products from *J. Bishop & Co.*, who also make stainless and nickel tubing for mechanical aircraft, capillary, and hypodermic applications.

1511. Stainless Tubing
Catalog 21 describes stainless steel tubing from *Superior Tube Co.* Needle tubing in gages from 6 to 33. All analyses, 0.010 to ⅝ in. O.D. Certain analyses in light walls up to 2½ in. O.D.

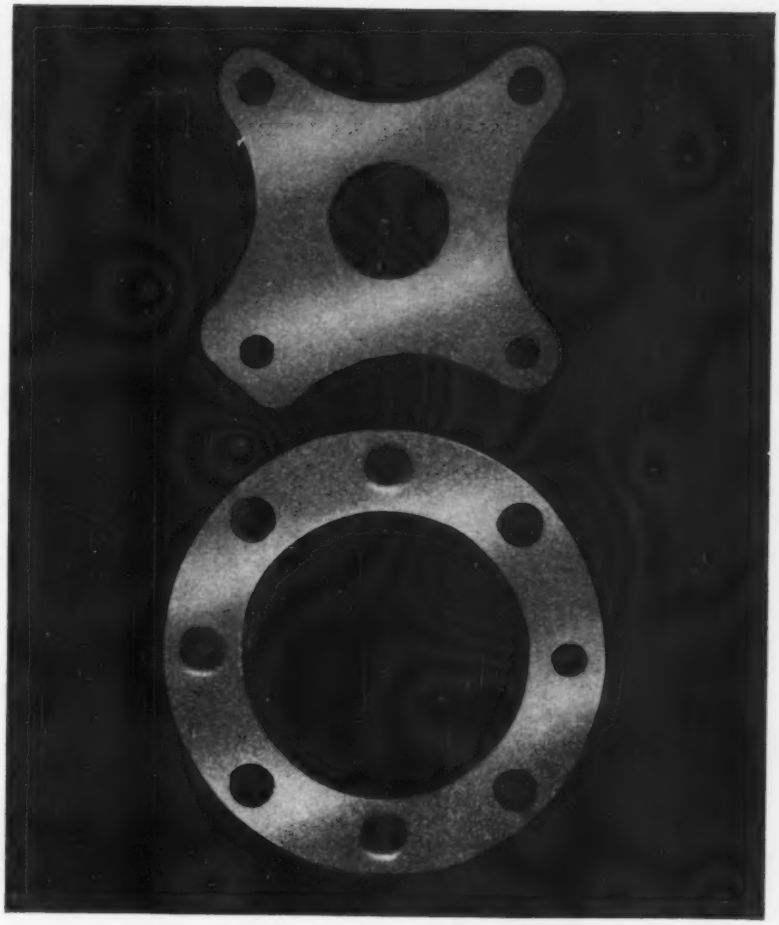
1512. Aluminum Chain
Flyer from *Bison Aluminum Chain Co.* describes weldless chain for applications in chemical plants and other areas with a corrosive environment.

1513. Industrial Springs
Alco Products has issued an 8-p. brochure covering the manufacture of and product data on a variety of springs for industrial use.

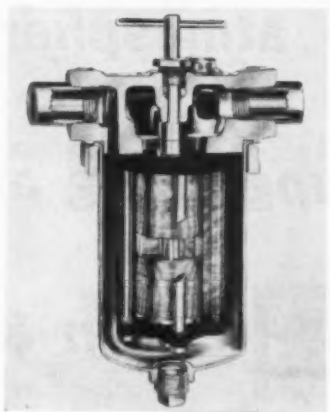
1514. Stainless Steel
Summerill Tubing Co. has released 4-p. guide to stainless tubing. Includes charts on size ranges, analyses, and standard tolerances.

1515. Aluminum Jacketing
Bulletin ICB from *Insul-Coustic Corp.* discusses aluminum jacketing for protecting the insulation on piping, tanks, or towers.

1516. Plant Facilities
20-p. booklet from *Eaton Mfg. Co.* discusses complete range of fabricating equipment available for solving production and developmenut problems.



These filter parts of VASCO Prealloyed Powdered Stainless Steel deliver high service at low cost in severe corrosion conditions!



Significant cost savings were realized by a leading Eastern filter manufacturer* when VASCO Prealloyed stainless steel powders were chosen for fabrication of these vital bridge and mounting plates. Powder metallurgy was a "natural" for the intricate shapes and close tolerance required . . . VASCO Prealloyed stainless was the ideal choice for better moldability and resistance to corrosion from many different liquids encountered in service. ● Do you have a need for greater production economy in your product? Talk to a VASCO powder metallurgy sales engineer!

*The Cuno Engineering Corp., Meriden, Conn.

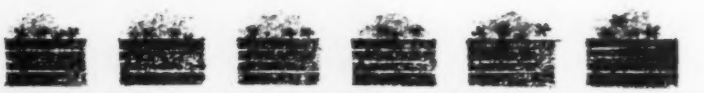
VA

Vanadium-Alloys Steel Company
POWDER METALLURGY DEPARTMENT
LATROBE, PENNSYLVANIA

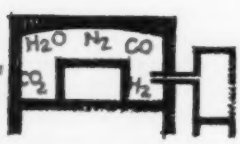
Circle 1609 on Page 48-B

IF you want to HEAT metal . . . .

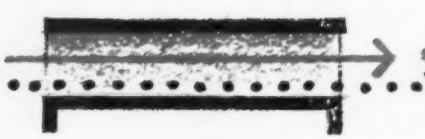
(melting, forging, brazing, sintering or treating) . . . . ferrous, nonferrous or exotic . . . . whether your parts travel one at a time **in batches**

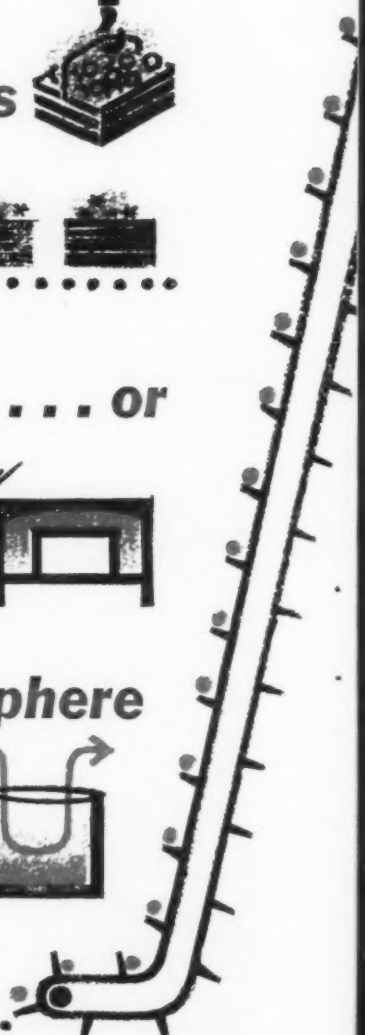
or in droves 

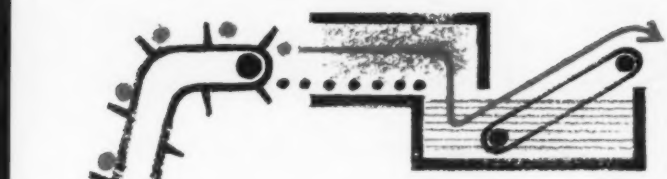
in a straight air atmosphere . . . . or in a protective atmosphere

or 

an upgrading atmosphere in & out. **down & up**

straight through 





or in a combination

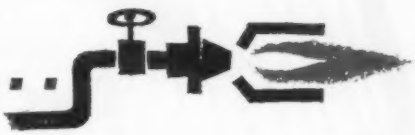
with manual operation

or automatic

AND if you want

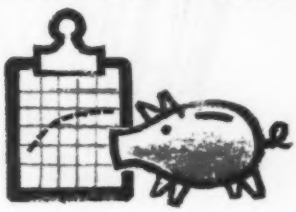
the economy of standard equipment

the least costly fuels . . .



PLUS known production rates and

pre-rated operating costs



WHAT DO YOU NEED? (pit, pot, box, link, muffle, tube, snap or lab furnace)

. . . SURFACE MAKES IT!

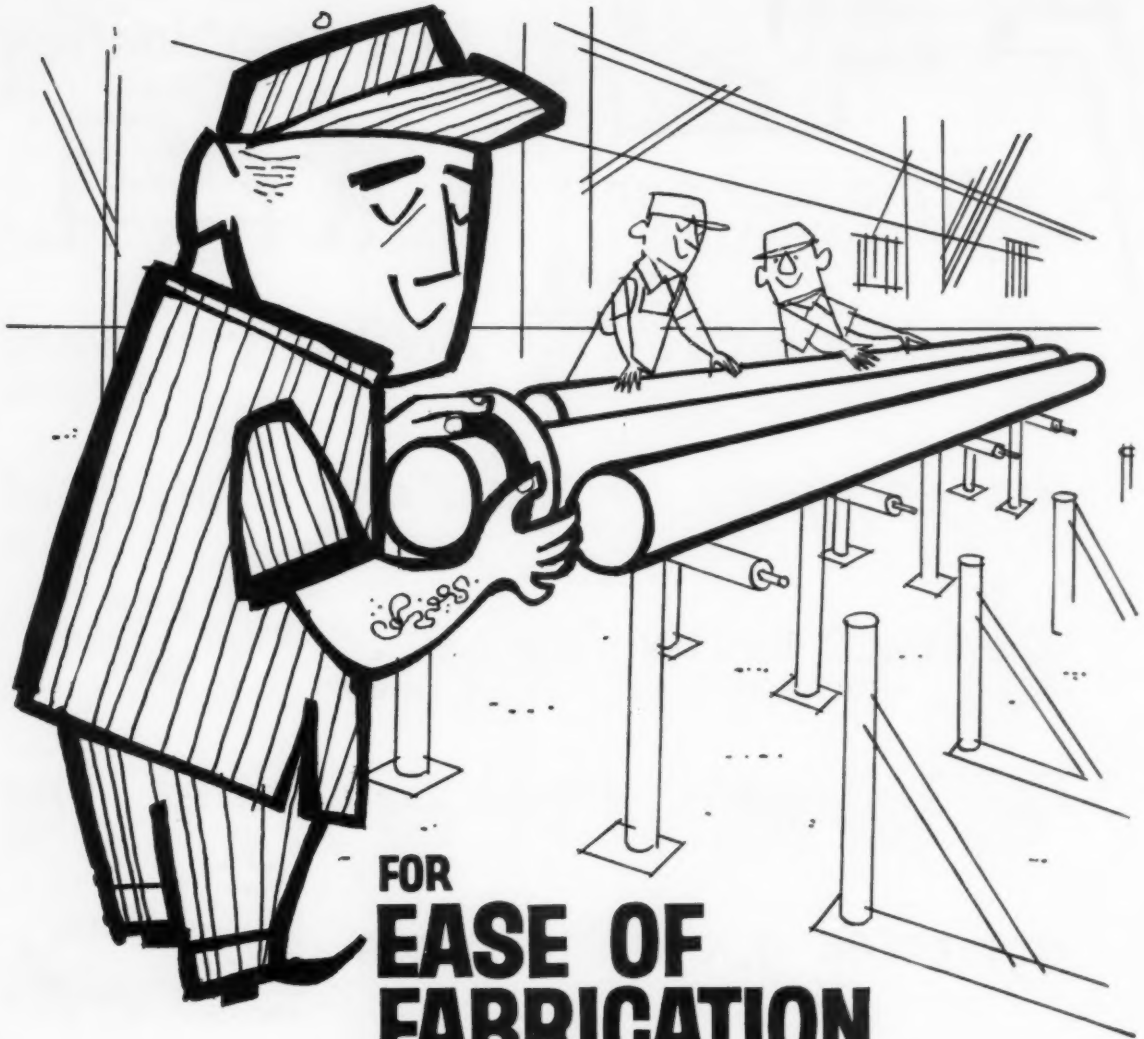
See us at the Metal Show
Booth 1540

Write for Bulletin SC-175. Surface Combustion, 2377 Dorr St., Toledo 1, Ohio.
In Canada: Surface Industrial Furnaces Ltd., Toronto, Ontario.

A division of Midland-Ross Corporation MR

Surface

Circle 1610 on Page 48-B



FOR EASE OF FABRICATION SPECIFY

B&W *Job-Matched seamless pressure tubing*

B&W's comprehensive quality control procedures help provide . . .

• dimensional accuracy • uniformity from tube to tube
• the precise mechanical properties you need
— these provide ease of fabrication

Quality is just one of the many reasons why it pays to specify B&W Carbon or Alloy Steel Seamless Pressure Tubing. And remember—matching tubes to jobs assures you long service life, and optimum low cost in addition to ease of fabrication. For more information call your local B&W District Sales Office or write for Bulletin TB-417. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pennsylvania.

B&W THE BABCOCK & WILCOX COMPANY

TUBULAR PRODUCTS DIVISION

TA-9056-SP3

Seamless and welded tubular products, solid extrusions, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels and special metals

The American Society for Metals and Metal Progress serve 32,000 member-readers in 11 major areas of the metals industry.

The ASM is the communications center for technical information wherever metals are produced, processed, fabricated, designed, tested and applied. Metal Progress, monthly engineering magazine of the Society, reports on engineering developments in these 11 major technological areas:

FERROUS METALS: Alloy, Carbon, Free Machining, Stainless Steels, Hot and Cold Finished Bars.

NONFERROUS METALS: Aluminum, Beryllium, Brass, Bronze, Columbium, Copper, Lead, Magnesium, Molybdenum, Monel, Nickel, Rare Earths, Tantalum, Titanium, Tungsten, Zinc, Zirconium.

HEAT- AND CORROSION-RESISTANT AND ELECTRICAL MATERIALS: Special Alloys; Carbon, Graphite; Ceramics, Cermets, Thermal Insulating and Special Electrical Materials.

RADIATION AND NUCLEAR MATERIALS & EQUIPMENT: Metallic and Non Metallic Reactor Materials, Fuel Elements, Pressure Vessels, Control Elements, Related Equipment.

TOOL MATERIALS, CUTTING AND FORMING EQUIPMENT: Abrasives; Carbides; Coolants, Oils and Lubricants; Arc and Gas Cutting Equipment, Saws; Forging, Pressing, Extruding, Chemical Milling, Slitting, Straightening, Spinning and Explosive Forming Equipment; Tool and Die Steels, Plastic and Other Short-Run Die Materials.

INDUSTRIAL HEATING EQUIPMENT AND SUPPLIES: Atmosphere Generators and Gases; Commercial Services; Furnaces; Controls, Indicators and Recorders; Induction, Flame and Salt Bath Equipment; Ovens; Cryogenic Equipment; Pyrometers; Quenches; Samplers and Analyzers; Trays, Refractory Parts.

CLEANING AND FINISHING EQUIPMENT AND SUPPLIES: Alkaline Cleaning, Pickling, Degreasing, Descaling, Buffing, Polishing, Blasting, Plating; Porcelain Enameling, Purifying; Painting Equipment and Supplies; Rust Preventives; Abrasives.

WELDING AND JOINING EQUIPMENT AND SUPPLIES: Gas, Resistance and Arc Welding Equipment and Supplies; Electrodes; Adhesives, Fasteners; Hard Surfacing, Brazing and Soldering Equipment and Supplies.

INSPECTION AND CONTROL EQUIPMENT AND SUPPLIES: Microscopes and Attachments; Analytical and Mechanical Equipment; Gages, Comparators, Hardness Testers, Nondestructive, Electronic and Other Scientific Inspection Equipment.

PRODUCTION AND CASTING EQUIPMENT AND SUPPLIES: Electric and Vacuum Furnaces and Equipment; Refractories; Ferro Alloys; Foundry Irons and Coke; Rare Earths; Alloying and Refining Agents; Annealing, Soaking and Sintering Furnaces; Rolling Equipment; Industrial Gases; Foundry Equipment and Supplies.

PARTS, FORMS AND SHAPES FOR DESIGN AND APPLICATIONS: Castings (Malleable, Gray Iron, Steel, Nonferrous), Forgings, Extrusions, Powder Metal Parts, Springs, Stampings, Tubing, Weldments, Wire.

FIRST CLASS
PERMIT NO. 1
NOVELTY, OHIO

BUSINESS REPLY CARD
No Postage Stamp Necessary if Mailed in U.S.

READER SERVICE DEPARTMENT
METAL PROGRESS
METALS PARK
NOVELTY, OHIO

October, 1960 Issue
METAL PROGRESS

FIRST CLASS
PERMIT NO. 1
NOVELTY, OHIO

BUSINESS REPLY CARD
No Postage Stamp Necessary if Mailed in U.S.

READER SERVICE DEPARTMENT
METAL PROGRESS
METALS PARK
NOVELTY, OHIO

October, 1960 Issue
METAL PROGRESS

Metal Progress October, 1960 issue
SEND COPIES OF THE FOLLOWING ARTICLES, FREE
Page No.
Title
Name:
Title:
Company:
Address: (Street)
(City) (Zone) (State)
Unnumbered Ads (Advertiser's Names)
If not an ASM member, please check box for complete information on membership advantages.
Cards not valid without company name, or if used after December 31, 1960.

Metal Progress October, 1960 issue
SEND COPIES OF THE FOLLOWING ARTICLES, FREE
Page No.
Title
Name:
Title:
Company:
Address: (Street)
(City) (Zone) (State)
Unnumbered Ads (Advertiser's Names)
If not an ASM member, please check box for complete information on membership advantages.
Cards not valid without company name, or if used after December 31, 1960.

Complete Reader Service Information With These Convenient, Prepaid Cards

Catalogs and bulletins, new products and services and most advertisements in Metal Progress are numbered. To receive more information, circle the appropriate numbers on one of these postage paid cards. Editorial reprints will be sent free as long as they last.

Catalogs and Bulletins are available from a *scrutinized* and up-to-date list of manufacturers' literature, conveniently indexed under the 11 major Engineering Areas.

More Facts on Advertised Products. Because some advertisements cannot be numbered, please write the names of those advertisers in the blanks provided.

New Products and Services are numbered. Circle the postcard for more information.

Reprints of Articles are yours for the asking as long as they last. No need to clip your Metal Progress issue for reference filing; send for reprints.

Please Include Your Name and Address!

Your best move is to UNITRON...

for a COMPLETE LINE of METALLURGICAL MICROSCOPES!

UNITRON'S Complete Line of Metallurgical Microscopes and Accessories covers the needs of Research, Industry and Education.

Quality optics . . . advanced optical and mechanical design . . . unique and convenient operational features . . . budget prices . . . free trial period — these, together with proven performance are the reasons why . . .

Circle 1520 on Page 48-B

THE TREND IS TO UNITRON

UNITRON

INSTRUMENT COMPANY • MICROSCOPE SALES DIV.
66 NEEDHAM ST., NEWTON HIGHLANDS 61, MASS.

Please rush UNITRON's Microscope Catalog 2-H

Name_____

Company_____

Address_____

City_____ State_____

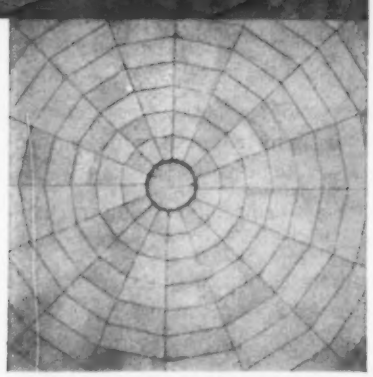
Bell-type annealing furnaces hold critical temperatures better—using J-M Superex

LEE WILSON ENGINEERING COMPANY, INC., STANDARDIZES ON J-M SUPEREX BLOCK INSULATION FOR PRECISION AND PERFORMANCE

In heat-treating furnaces, at temperatures to 1900F, Johns-Manville Superex® Block insulation provides greater efficiency and long operating life . . . because of its unique combination of low conductivity and low shrinkage at elevated temperatures. Control of critical processing temperatures is reached *and held* more easily.

Especially formulated from diatomaceous silica and asbestos, the large, strong, lightweight blocks of J-M Superex are cut with such careful precision that a furnace dome will support the weight of several workers during construction...*without any cement being used!*

This ideal combination of performance advantages and production skill is the reason Lee Wilson Engineering Co., Inc., employs J-M Superex for wall and dome insulation. It will pay you to insist on J-M Superex in your high-heat equipment. Write for details to Johns-Manville, Box 14, N. Y. 16, N. Y. In Canada: Port Credit, Ont. Cable: JOHNMANVIL



Inside Looking Up...*view from below the dome of a Lee Wilson bell-type furnace. Note close fitting between Superex blocks. This dome actually supports installation workers' weight* . . . without use of cement!

ONLY J-M SUPEREX BLOCK INSULATION GIVES YOU ALL THESE ADVANTAGES:

High Compressive Strength – only ⅛" compression under 85 lbs psi

Low Conductivity – .82 at 1000F mean temperature

Low Heat Shrinkage – 2.7% linear shrinkage at 1900F

Large Size Blocks – 12" x 36" blocks speed application, reduce number of joints. Yet blocks are light in weight for ease of installation

Lightweight – only 24 lbs per cubic foot

JOHNS-MANVILLE

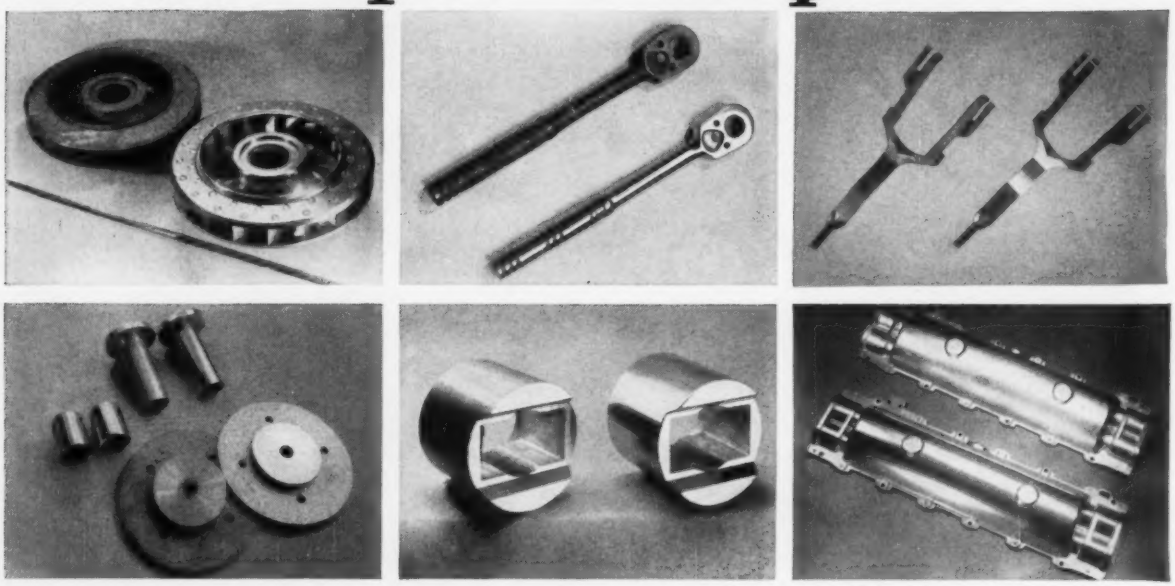
AN INSULATION FOR EVERY COMMERCIAL AND INDUSTRIAL USE

JOHNS-MANVILLE JM PRODUCTS

Circle 1529 on Page 48-B

AIR-CUSHIONED

vibration



These photos prove it! Pangborn Vibratory Finishing gives the kind of finishing you never had before!

Pangborn Vibratory Finishing—culmination of years of experimentation and refinements*—is the newest method for cleaning, descaling, deburring, grinding, radiusing, fine-finishing, coloring and burnishing all metal and metal alloy parts, suitable plastic and ceramic items.

This unit gives you versatility of application, larger payloads and greatly-reduced time cycles resulting in tremendous savings. It easily handles parts too delicate or intricate to finish by other methods . . . shielded areas and interior surfaces . . . even coarser jobs faster and better.

In a wide range of sizes. Also auxiliary equipment, media and compounds for every need. Send parts with exact finish specifications, or finished specimen, for sample processing in our laboratory to: Mr. William E. Brandt, PANGBORN CORPORATION, 1800 Pangborn Blvd., Hagerstown, Maryland.

- Actually works up to 100 times faster than conventional methods; does more work better at lower cost
- Does work impossible to do by barrel finishing or other means
- Most compact vibrator on the market
- Air cushion support and suspension for automatic leveling and amplitude control supplants spring suspension systems subject to fatigue
- Standard basic machines are equipped with mechanically variable speeds
- Floor vibration entirely eliminated, making possible (for the first time) second floor mounting

* Pat. No. 2,422,786; June 24, 1947

Pangborn
OF HAGERSTOWN

Circle 1523 on Page 48-B

INTERLOX...

a better, lower cost, easily controlled phosphate coating that LOCKS your finish to the metal.

Interlox's unusual cleaning ability and radically different type of accelerator produce an even, fine grained, dense coating that literally locks an organic finish to the metal.

Interlox gives you the ultimate in appearance, adhesion and corrosion resistance—no streaks, stains, powdery residue or flash rusting to complicate your production. Interlox baths are unusually long lived and require less replenishment and control.

Extra cleaning power is easily obtained at any time by the addition of a low-cost detergent only. This avoids the danger of over-phosphatizing by the costly practice of adding complete phosphatizing compound when only cleaner is needed.

There is an Interlox product to meet your particular requirements, whether spray or immersion type, single or multiple stage.

Licensed Manufacturers { **Alert Supply Co., Los Angeles, California**
Armalite Company, Ltd., Toronto, Canada

NORTHWEST CHEMICAL COMPANY
9310 ROSELAWN **DETROIT 4, MICHIGAN**

Circle 1524 on Page 48-B

Kanigen®

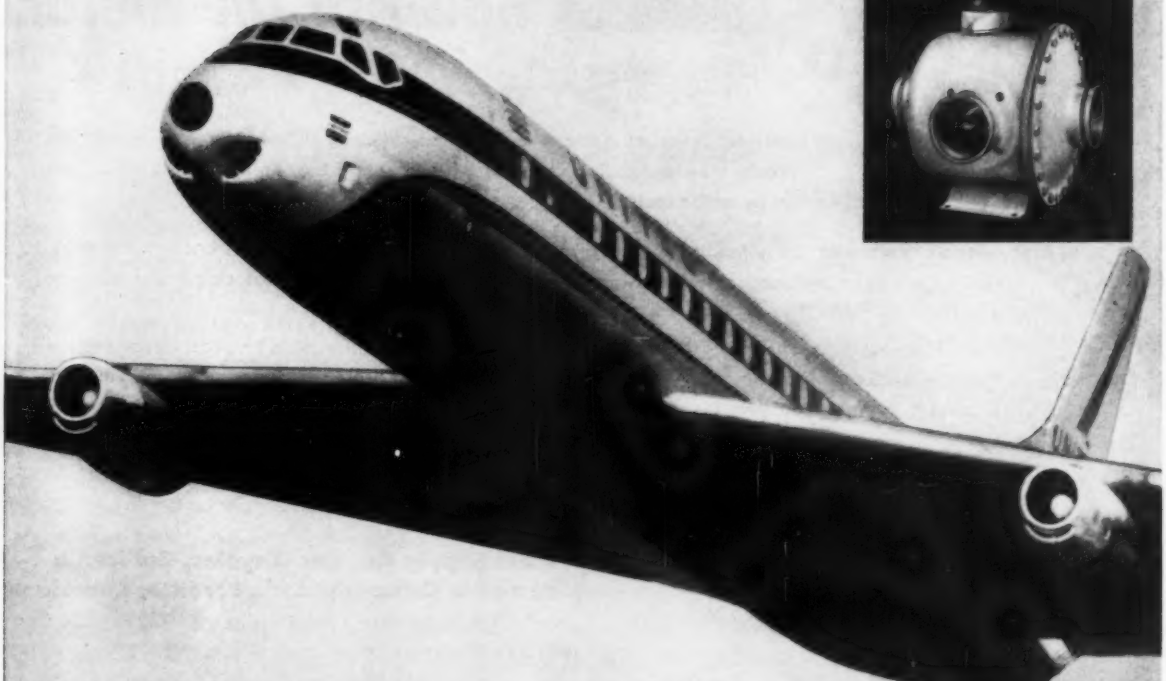
helps keep jet aircraft where the money is ...in the air

Big jet aircraft make money only when they are in the air. Every minute they are earthbound is costly. You just can't take chances on failure of aircraft engines from fuel contamination, or on failure of refueling equipment. That's why those parts of Brodie BiRotor refueling meters and control valves that come in contact with the fuel are chemically plated with KANIGEN nickel alloy.

Brodie BiRotor meters have been used for controlling aircraft refueling for many years, and their internal parts have been KANIGEN-coated ever since this highly accurate method of plating difficult or complicated surfaces was perfected.

Do you have a corrosion or contamination problem? Is it a small part like the Brodie meter housing? Or is it a surface as large as the inside of a 20,000 gallon tank car? Whatever it is, there's a way to solve your problems with KANIGEN chemical nickel plating. Write or phone the nearest General American office.

It pays to plan with General American.

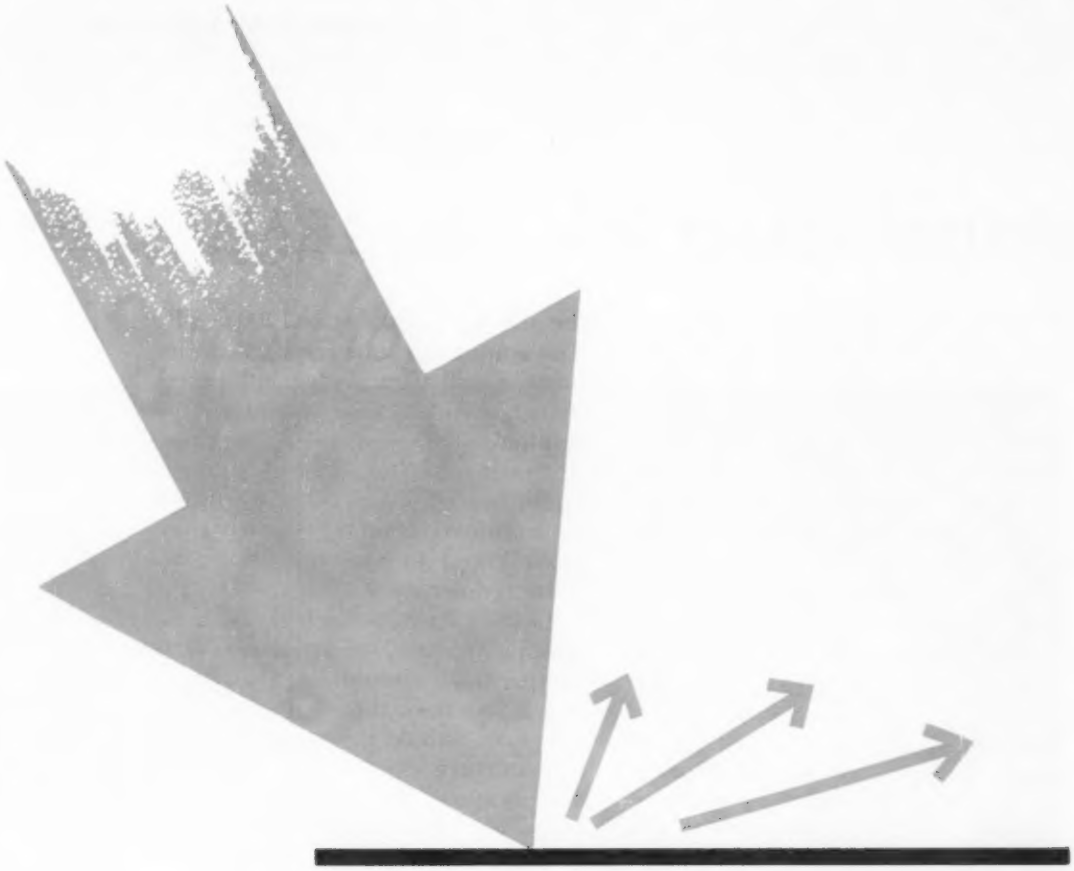


GENERAL AMERICAN TRANSPORTATION

KANIGEN DIVISION
CORPORATION
135 South LaSalle Street
Chicago 3, Illinois
Offices in principal cities

KANIGEN GENERAL AMERICAN

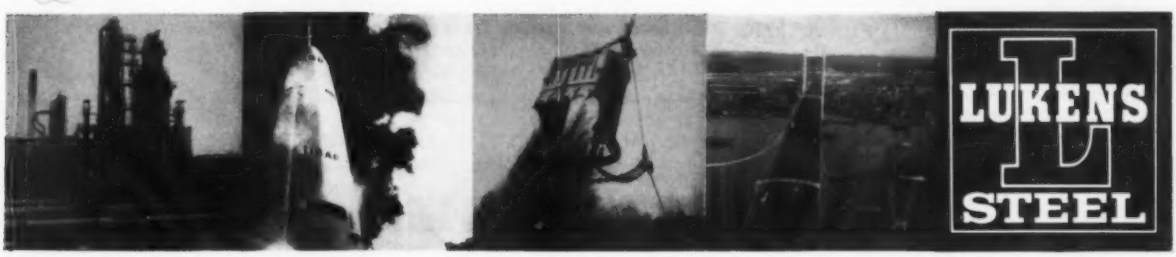
Circle 1612 on Page 48-S



Metallurgical Phenomena... and the metals to cope with them.

These are the stock-in-trade of the Lukens Application Engineer—whether the problem be one of abrasive impact (symbolized above) or corrosion or pressure or structural stress or high and low temperature. Investigation of the best steels for "problem" applications has been carried on for years by the Lukens Application Research team. We would welcome the opportunity to contribute the results of this research to your own design knowledge. Please contact us in your early design stages. Call collect: Joe Proctor, Manager of Application Engineering, Extension 422, Lukens Steel Company, Coatesville, Pennsylvania.

HELPING INDUSTRY CHOOSE STEELS THAT FIT THE JOB



Circle 1525 on Page 48-B

KNOW YOUR ALLOY STEELS . . .

This is one of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

Thermal Stress-Relieving of Alloy Steels

In the production of alloy steel bars and parts made of alloy steel, stresses are sometimes set up, and these stresses must be relieved before optimum results can be expected. Two general types of stress-relieving are practiced—thermal and mechanical. In this discussion we shall consider only the former.

There are several important reasons for thermal stress-relieving. Among these are the following:

(1) The first and most fundamental purpose is to reduce residual stresses that might prove harmful in actual service. In the production of quenched and tempered alloy steel bars, machine-straightening is necessary. This induces residual stresses in varying degrees. Bars are usually stress-relieved after the straightening operation. When the bars are subjected to later processing that sets up additional stresses, subsequent stress-relieving may be necessary.

(2) A second major purpose of thermal stress-relieving is to improve the dimensional stability of parts requiring close tolerances. For example, in rough-machining, residual stresses are sometimes introduced, and these should be relieved if dimensional stability is to be assured during the finish-machining.

(3) Thermal stress-relieving is also recommended as a means of restoring mechanical properties (especially ductility) after certain types of cold-working. Moreover, it is required by the "safe-welding" grades of alloy steels after a welding operation has been completed.

Alloy bars are commonly stress-relieved in furnaces. Temperatures under the transformation range are employed, and they are usually in the area from 850 deg to 1200 deg F. The amount of time required in the furnace will vary, being influenced by grade of steel, magnitude of residual stresses caused by prior processing, and mass effect of steel being heated. After the bars have been removed from the furnace, they are allowed to cool in still air to room temperature.

In the case of quenched and tempered alloy bars, the stress-relieving temperature should be about 100 deg F less than the tempering temperature. Should the stress-relieving temperature exceed the tempering temperature, the mechanical properties will be altered.

Items other than bars (parts, for example) can be wholly or selectively stress-relieved. If the furnace method is used, the entire piece is of course subjected to the heat; selective relieving is impossible. However, if a liquid salt bath or induction heating is used, the piece can be given overall relief or selective relief, whichever is desired.

Detailed information about stress-relieving is available through Bethlehem's technical staff. And remember that we can furnish the entire range of AISI standard alloy steels, as well as all carbon grades.

This series of alloy steel advertisements is now available as a compact booklet, "Quick Facts about Alloy Steels." If you would like a free copy, please address your request to Publications Department, Bethlehem Steel Company, Bethlehem, Pa.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

Circle 1526 on Page 48-B

"Is that the new Norton catalog?"

You bet it is!

It's dog-eared and marked up because it's in constant use by men who want better materials — high purity refractory materials which will stand up under the most extreme thermal, mechanical, chemical, electrical, and radioactive conditions.

This valuable, well-illustrated reference describes in detail the many Norton refractory materials which are helping to solve widely different product and processing problems. Uses range from aiding chemical reactions to stopping neutrons, handling molten metals, protecting rocket engines — and taming lightning.

Catalog lists physical, chemical and electrical properties of CRYSTOLON* Silicon Carbide, ALUNDUM* Aluminum Oxide, MAGNORITE* Magnesium Oxide, NORBIDE* Boron Carbide, and Fused Zirconia. It's thought-provoking...a real "idea-starter!"

You may well profit from this book in solving your own processing problems. No charge or obligation, of course, write for "Norton Refractory Grain," NORTON COMPANY, Refractories Division, 329 New Bond St., Worcester 6, Mass.

*Trade-Marks Reg. U.S. Pat. Off. and Foreign Countries

NORTON
REFRACTORIES
Engineered... Rx ...Prescribed

75 years of... Making better products ... to make your products better

NORTON PRODUCTS: Abrasives • Grinding Wheels • Machine Tools • Refractories • Electro-Chemicals — **BEHR-MANNING DIVISION:** Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

Circle 1527 on Page 48-E

These advantages yours–with Timken®

COMPLETE SERVICE—FAST DELIVERY

Call these modern Steel Service Centers

LOCATION	STEEL SERVICE CENTER
ALABAMA	
Birmingham	O'Neal Steel, Inc.*†
ARIZONA	
Phoenix	Earle M. Jorgensen Co.*†•
CALIFORNIA	
Los Angeles	Allen-Fry Steel Company*
	Baker Steel & Tube Co. •
	Coulter Steel & Forge Co.*†
	Earle M. Jorgensen Co.*†
	Kilsby Tube Supply, Division of Republic Supply Co. of Calif.•
	Joseph T. Ryerson & Son, Inc.*•
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Denver	Earle M. Jorgensen Co.*†•
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Atlanta	A. Milne & Co., Inc.†
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MISSOURI	
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Linden	Bowsteel Distributors Corporation*
Newark	Faitoute Iron & Steel Company, Inc.*
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OHIO	
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Cincinnati	Ford Steel Company†
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Portland	Pacific Machinery and Tool Steel Co.†
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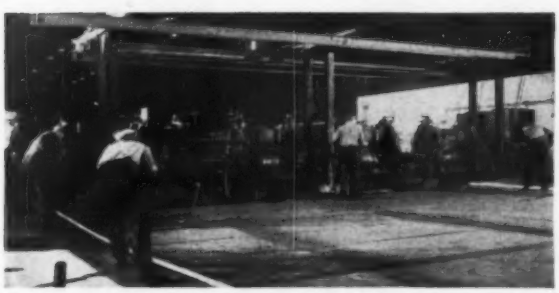

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Circle 1528 on Page 48-E

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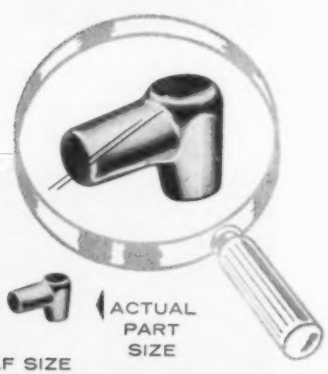
BRASS, BRONZE, ALUMINUM FORGINGS

The two parts shown here dramatically illustrate the ability of the Mueller Brass Co. to produce precision forgings regardless of size or configuration. Both the tiny dental drill nozzle and the big heat exchanger shell hub, which is the largest of its kind ever produced, were forged to exacting specifications. The weight of the nozzle is only a few ounces while the shell hub weighs 40 lbs., and has a forged pocket 7 1⅝₆″ in diameter and 4⅜₆″ deep. By way of size comparison, the pocket is big enough to hold over 14,000 of these tiny drill nozzles. By forging the pocket, considerable machining time and money was saved. The sound, dense structure of the shell hub makes it ideal for the high pressure application for which it was designed. The forging not only does the job better, but was produced for 25% less than the casting it replaced. Experience makes it possible for the Mueller Brass Co. to produce high quality precision forgings regardless of specifications . . . why not put this experience to work for you?



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MUELLER BRASS CO.

Circle 1521 on Page 48-B

PARTS ECONOMICALLY...TO EXACT

METAL, METHOD OR SIZE...

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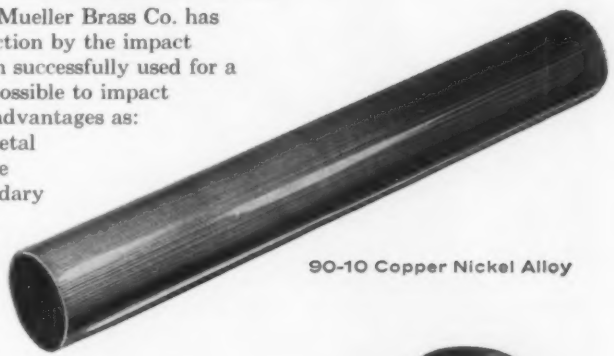
The parts shown here are representative of the group now being economically produced as impact extrusions by the Mueller Brass Co. who offer complete engineering and design service in the development of new parts from copper base alloys.

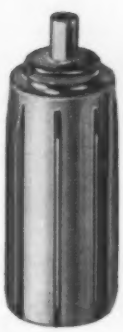


90-10 Copper Nickel Alloy

Aluminum Alloy 6061

Oxygen Free High Conductivity Copper

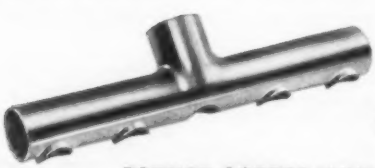
Special Alloy 902



Tellurium Copper Alloy

Low Phosphorus Copper Alloy

SOURCE FOR ALL THESE OTHER PRODUCTS



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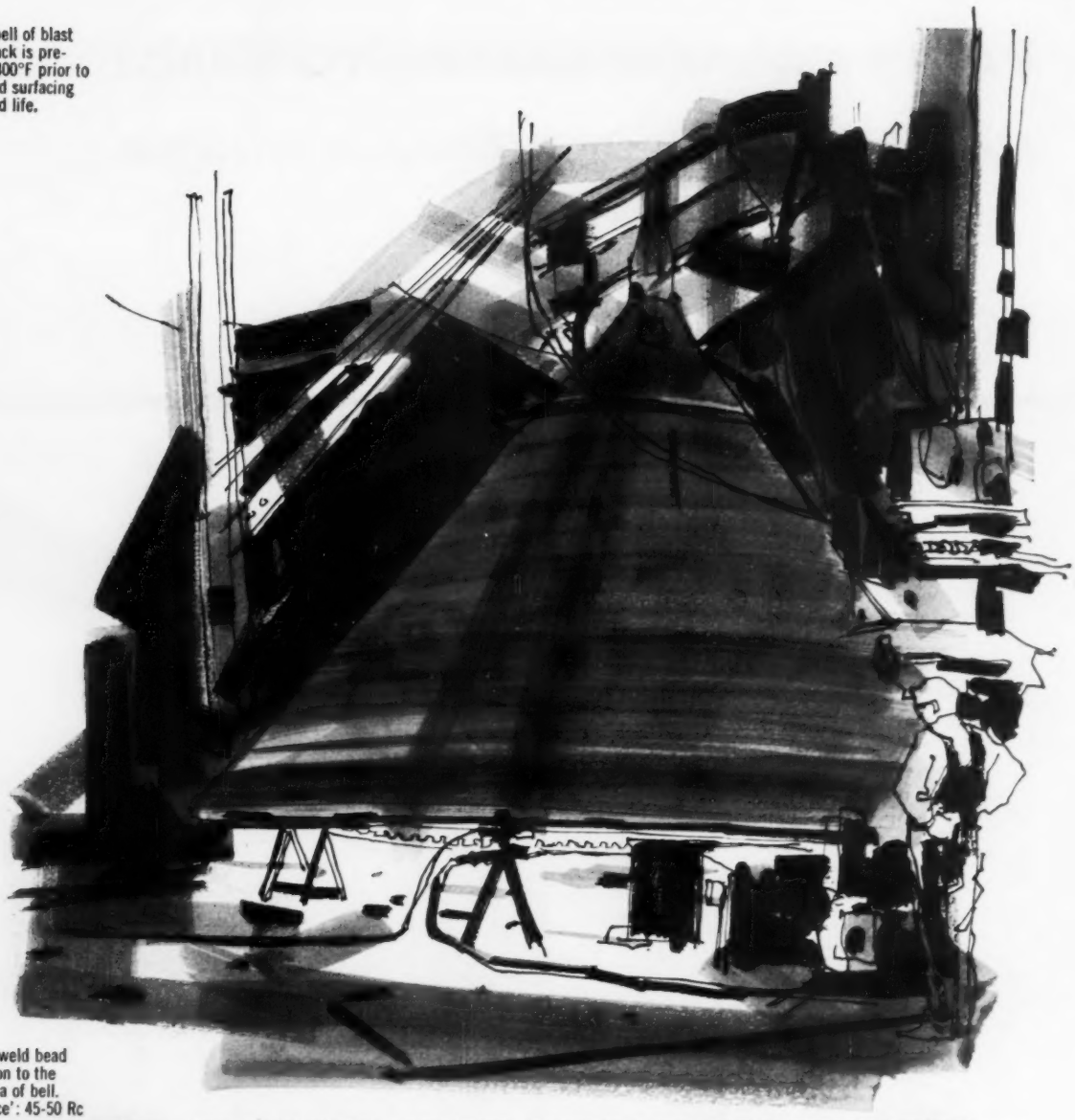
Circle 1522 on Page 48-B

■ Giant bell of blast furnace stack is pre-heated to 400°F prior to Mahon hard surfacing for renewed life.



■ A hard-weld bead is spiraled on to the working area of bell. 'New Surface': 45-50 Rc

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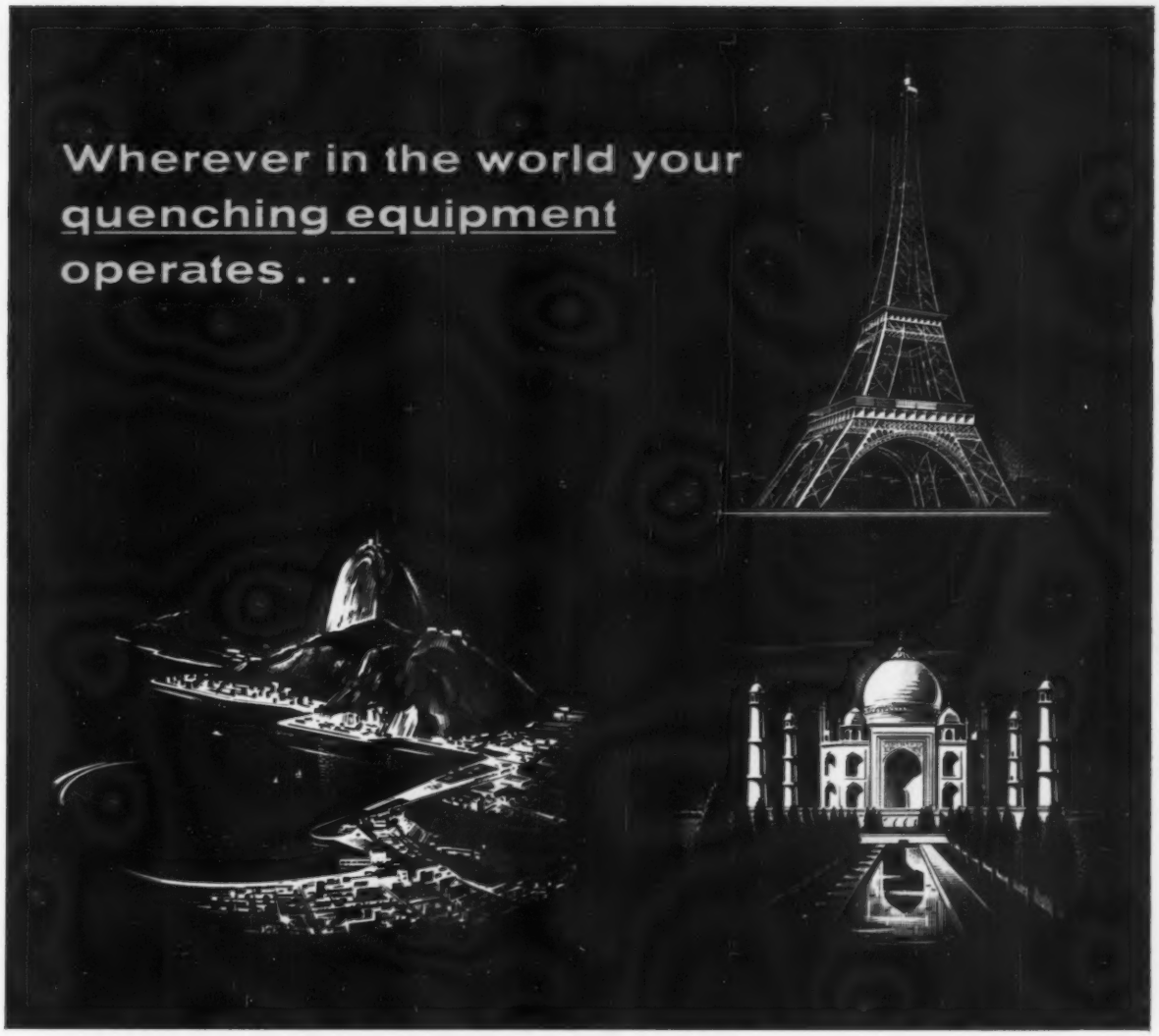
Circle 1530 on Page 48-B



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Circle 1532 on Page 48-B

Metal Progress

Vol. 78, No. 4 October 1960

Technical NEWS in Brief

Tensile-Impact Test Reveals Best Hot Working Temperature

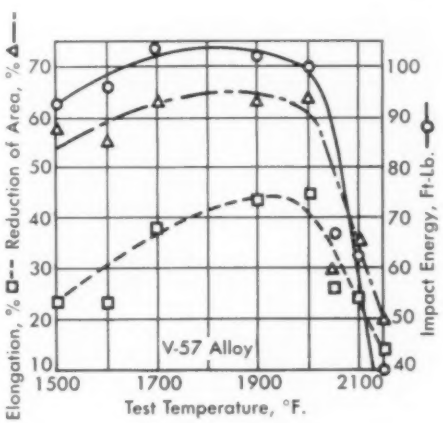
Hot working of many alloys for high-temperature applications has proved difficult because of the narrow range in which it must be done. To provide enough data for establishing the best working temperature, metallurgists at Carpenter Steel Co., Reading, Pa., suggest a tensile-impact test in which hot specimens are broken in a modified Sonntag universal impact machine. Impact strength, elongation and reduction of area can be determined for an alloy over a range of temperatures.

The advantages of the method are that it is simple, fast and relatively inexpensive. Specimens are held at the desired temperature for a minimum of 30 min., then placed in the testing machine and broken within 4 sec. Plotted as a function of temperature, the tensile-impact properties indicate the hot working range of the alloy.

According to Gerald B. Heydt, supervisor of high-temperature alloy research, data show that with most alloys, impact energy, elongation and reduction of area fall off markedly just above the maximum allowable hot working temperature. At the lower limit of the range, the properties again drop off but not as abruptly. This is pointed out in the curve (see figure) for Carpenter's V-57 alloy (0.05 C, 14 Cr, 26.5 Ni, 1.5 Mo, 3.0 Ti, 0.25 Al, 0.007 B) in wrought form. Permissible working temperatures lie between 1700 and 2000° F.

Generally, the impact energy, ductility and maximum permissible hot working temperature of as-cast alloys are lower than those of wrought material. This correlates well with mill experience in that a difficult-to-work alloy will usually exhibit improved workability once the as-cast structure has been at least partially broken down. Reduction from ingot to billet is more difficult than subsequent reduction of the billet.

Tests are now being conducted on many types



Results of Hot Tensile-Impact Tests
Change in Properties Indicates Best Hot Working Range

of alloys to determine the over-all usefulness of the tensile-impact test. This program will attempt to correlate data from the hot tensile-impact test, hot tensile test, cone forging test and mill experience.

Higher Molybdenum and Silicon Improve 4330

Metallurgists at Frankford Arsenal in Philadelphia have come up with a new high-strength steel which is based on a modification of the 4330 series (molybdenum has been raised to 0.5%, silicon to 1.6%). The alloy is intended for critical, highly stressed ordnance components. C. M. Carman, metallurgist in the Arsenal's research and development department, reports that it will develop a yield strength of 220,000 psi. and a tensile strength of 250,000 psi. Reduction in area in the longitudinal direction of forgings is greater than 40%. Transverse reduction in area is usually 30%, and fracture toughness of the alloy represents some improvement over 300M.

Arc Heater Raises Gases to Ultra-High Temperatures

An electrical arc heater which has a potential of generating a gas stream of 20,000° F. has been devised. Composed of hollow doughnut-shaped electrodes placed horizontally one over the other, it works by transferring heat from an electrical arc to a gas. During tests, a unit built under the direction of Armin Bruning at Westinghouse Electric's East Pittsburgh, Pa., plant maintained an arc temperature of 10,000° F. and accelerated the gas to 3400 miles per hr. Obviously, these conditions will help duplicate in a wind tunnel those met by spacecraft during re-entry into the atmosphere. Other potential uses are in processing metals with high melting points such as tungsten and as a chemical synthesizer – for instance, in producing nitrous oxide.

ELECTRODES FOR ARC HEATER
Rotating Arc Between Electrodes Heats Gases to 10,000° F.

In operation, the electric arc is started between the electrodes and is then rotated at high speed around the gap by a magnetic field. Arc rotation and water cooling of the electrodes reduces contamination of the gas to 0.2% maximum. Air or nitrogen enters the arc chamber, passing through openings near a watercooled copper heat shield. After leaving the arc, the gas is ejected through a water cooled nozzle. Prototypes are designed to accommodate 1.2 lb. per sec. flow of air or nitrogen and should supply gas at 1500 psi. with a constant enthalpy for as long as 10 min. without damage to the chamber.

Aluminum Cans Made by Impact Extrusion

With an eye toward decreased shipping costs, a number of industries whose products are packaged in cans are turning to aluminum. Although surveys show that only 2% of the cans produced in this country are made of the light metal, they point toward an upward trend. This is typified by a West Coast brewery which will soon take delivery of an impact extrusion press capable of knocking out two aluminum cans per sec.

Built by National Machinery Co., Tiffin, Ohio, the press extrudes seamless cans with a wall thickness of 0.013 in. (+ 0.000, − 0.004 in.) from disks measuring 2½ in. diameter and ⅛ in. thick. These slugs are punched from continuous-cast 1100 alloy strip, coated with a wax lubricant and fed to the machine through a vibratory hopper. Cans are then trimmed, flanged, cleaned, coated, filled and closed.

Cost of the aluminum cans made by impact extrusion is said to be close to that of tin cans of conventional thickness (0.009 in.). Tool life is good – over 40,000 cans have been produced with no signs of wear on the die and ram.

New Theory Explains Corrosion of Iron

The standard explanation of corrosion attributes it to the formation of tiny electrical cells which set up minute currents on the surface of the metal. Research into the cause of rusting of iron, however, reveals that hydrogen ions or protons may be more influential.

By observing corrosion of pure iron wires exposed to either dry oxygen or water vapor at 835° F., scientists at Westinghouse Research Laboratories have concluded that hydrogen ions from water vapor enlarge the areas of chemical reaction between the oxygen and iron and thus accelerate corrosion. In dry oxygen the iron takes on a protective oxide coating from which tiny oxide whiskers grow; in water vapor iron oxide grows

as thin blade-shaped platelets and the amount of rust formed is 250 times greater than when no hydrogen ions are present.

At lower temperatures this effect is masked by complex corrosion products. According to E. A. Gulbransen, who with T. P. Copan did the experimental work, two measures, in addition to accounting for electrochemical effects, must be considered in controlling corrosion: Prevent hydrogen from entering the metal and add suitable alloying elements to inhibit growth of the localized reaction sites.

Iron Recovered From Tailings of Sulphide Ores

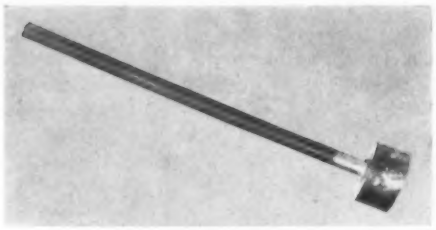
It is well known that nearly all of the world's production of copper, lead and zinc comes from sulphide ores. Modern recovery methods start with a separation of the finely ground ore into concentrates and tailings, the latter usually containing much pyrite or iron sulphide. There have been many abortive attempts made to recover the iron from these tailings, but it was not until recently that this work was rewarded. Successful operation of a pilot plant has encouraged Consolidated Mining & Smelting Co. of Canada to build an iron smelter at Kimberly, B. C., which is expected to be in production before the end of 1960. It will stand near a tailings dump containing over 15,000,000 tons of iron accumulated during many years of operation of one of the world's largest lead-zinc mines.

The tailings will be cleaned and the concentrate roasted to an oxide "ore" containing about 65% iron (the sulphur going into a sulphuric acid plant). The raw material, 85% of which will pass through a 325-mesh screen, is mixed with coke fines and agglomerated into ¼-in. pellets which are then converted into a partially slagged sinter. The crushed sinter, with more coke and dolomite flux, will be charged continuously into a submerged-arc electric furnace whose product is a pig iron containing 4% carbon and 1 to 2.5% silicon.

Tungsten Formed at High Velocity

Tungsten retains much of its strength up to about 4000° F. and for this reason it is difficult to work. In recent tests at N.A.S.A., for example, the best reduction achieved with a standard extrusion press was 8:1 starting with the tungsten slug clad with columbium and using a lubricant of powdered glass and graphite.

By working tungsten in a high-energy extruding and forging machine, engineers at Convair Div., of General Dynamics Corp., San Diego, have obtained reduction ratios of up to 45:1 without cladding or lubrication. The machine, called Dynapak (see *Metal Progress*, October 1959, p. 111), works the metal at such a high rate that recrystallization occurs. Wear and tear on extrusion and forging dies are decreased and the tungsten can be processed within a broader temperature range (3000 to 3800° F.) than when conventional machines are employed.



EXTRUDED TUNGSTEN
Reduction Ratios of 45:1 Are Possible in High-Energy Machine

From Here and There

Bureau of Naval Weapons has awarded a contract to cover a study of the production of molybdenum alloy sheet. Two alloys, 0.5% Ti molybdenum and 0.5% Ti, 0.07% Zr molybdenum are being investigated by Universal-Cyclops Steel Corp., Bridgeville, Pa. Purpose of the program is to examine several methods of processing molybdenum from ingot to plate and to compare single and double vacuum arc melting. The best method will be used to produce 4000 lb. of sheet of each alloy.

• • • •

Thin gold coatings to reflect cosmic radiation will be applied to steering jets for space vehicles. The small jets are electropneumatic controllers about the size of a hand and are used to keep space craft from tumbling and spinning. Engineers of Bendix Corp., New York, report that a coating only 0.000040 of an inch thick reflects up to 95% of all radiation. Controllers are first sprayed with an epoxy, then placed in a vacuum chamber where vaporized gold deposits on their surfaces. Once coated, each controller is baked.

Report on Progress in High-Temperature Materials

A noteworthy outcome of the recent conference on the mechanical properties of engineering ceramics is that there is an increasing trend toward correlation of mechanical properties of ceramics with their internal structure and constitution. This point is brought out in one of four articles which make up "Progress in High-Temperature Materials" coming in next month's *Metal Progress*. Also included in the package will be an up-to-date report on refractory metals and comprehensive articles on how to fabricate and braze René 41, one of the most promising superalloys.

U^{235} to a Stockpile?

On June 27 the Soviet's bloc of delegates walked out of a meeting in Geneva of the United Nation's Committee of Ten considering disarmament. The United States' representative was about to present new proposals for the limitation of nuclear explosives, and these have now been given to a meeting of the United Nation's Disarmament Commission (an 82-nation body) on Aug. 16:*

Goals – We want a world at genuine peace, not the fearful peace of an armed truce. The quest for disarmament is long and difficult. . . . Our fundamental goals are these:

We want a world in which all nations and peoples are secure from aggression and can shape their destinies in freedom.

We want a world of open societies in which peoples are no longer separated by barriers of official secrecy and hatred.

We want a world whose rich resources and spectacular scientific prowess will be used not for conquest, nor for defense against the fear of conquest, but only for the welfare of mankind and the growth of the human spirit.

We want world peace under law which is inspired by justice.

And we want the kind of disarmament – which is both fair and fully verified – which will help the world toward those great ends.

Provisions – The United States brought to the Ten-Nation talks certain basic convictions:

A sound disarmament plan must be broad enough in scope to take in all kinds of armaments and armed forces.

It must be concrete and realistic, tied to the growing complexity of modern weapons.

It must move step by step, always under adequate control, toward the ultimate goal of complete and general disarmament under effective international control.

It must be so fair at every stage that no country will gain a military advantage.

It must include procedures for settling international disputes peacefully, in accordance with the Charter of the United Nations, after complete and general disarmament has been achieved.

Finally, a sound disarmament plan must reduce the enormous risks which exist today, which present a real danger of war by accident or miscalculations, and which give a great impulse to the arms race.

Transfer of U^{235} – Only in one field related to disarmament – that is, the cessation of nuclear weapons tests – have we had any real promise of success. Progress there is slow, but the discussions are going on. The United States refuses to be discouraged, and as proof I present today two new proposals:

The first relates to ending the production of fissionable materials for weapons purposes. In the past the United States has proposed that when this production was cut off, agreed quantities of fissionable materials be transferred, under international supervision, from existing accumulated weapons stocks to peaceful uses – thereby reducing directly the number of nuclear weapons now in national arsenals. The United States is ready, on a reciprocal basis, to transfer to international supervision 30,000 kg. of weapons grade U^{235} as the amount which the United States and the Soviet Union would each initially transfer.

Let me say by way of explanation that 30,000 kg. of weapons grade U^{235}, if used in our modern nuclear weapons, would generate an explosive force well over 1000 times greater than that of *all* the high explosive bombs dropped by *all* the warring powers during World War II. The transfer of that amount to peaceful uses by the United States, and an equal amount by the Soviet Union, would mean an immediate and sizable reduction in the nuclear threat. It would be a real and a practical measure of disarmament.

Stop Production – If the Soviet Union is not prepared to join in a plan of this kind, I am authorized to propose a second direction in which we might now make a start.

The United States is ready to join the Soviet Union in halting by successive steps the production of fissionable materials for weapons use. We are prepared to shut down, one by one, under international inspection, our major plants producing enriched uranium and plutonium, if the Soviet Union will shut down equivalent facilities.

We are prepared to do this *now* – with no delay at all.

Soviet Reaction – Text of the reply of the Soviet's representative, Mr. Kuznetsov, is not available. The *New York Times* reports that he "bluntly rejected both proposals, saying that stockpiles of weapons of fearful power would still be left, even with the transfer of 30,000 kg. of U^{235} to a stockpile and the closing of production plants. He also said that the United States still continues to advocate control (spying) without disarmament (as advocated by Premier Khrushchev), namely, a ban on all nuclear weapons and the prohibition of production and delivery." The Editors of *Metal Progress* speculate that such a transfer of 30,000 kg. U^{235} might strip the Soviet of a major fraction of its weapons-grade uranium.

*From here to the beginning of the last paragraph the text is quoted verbatim from Ambassador Lodge's presentation.

M
P

Special Report

for TECHNICAL MANAGEMENT IN METALWORKING

Why Technology Is More Important Than Ever . . . Manufacturers in the metalworking industry are faced with a severe problem of keeping costs in line to stay competitive. There is pressure from increasing wages and higher-cost materials, yet boosting prices isn't easy in the present state of competition. This means that management must look to improved technology for programs designed to cut costs and step up efficiency of their operations.

More than ever before, the technical management men of the metalworking industry will be seeking vital information such as presented in the special reports which follow, to guide them in selecting metals, their fabrication and processing.

Technical Management at Work – R. E. Harvie (standing), chief metallurgist of Chevrolet's engineering department, discusses steel selection problem for camshaft and gear with other G.M. engineers. With direct ties to a price-conscious public in a highly competitive industry, auto makers were among the first to recognize a new trend in steel applications: Aided by wise selection and improved processing methods, the most effective way to achieve reduced production costs without sacrificing quality is to make the most of the engineering properties of modern steels.

A Report to
Technical Management

How to Get More From Modern Steels

Progress in steels means improved materials for many applications. Here's a report for the idea-minded on possibilities with . . . high-strength materials . . . carbon, leaner alloy and H-steels . . . leaded grades . . . steels for cold extrusion . . . vacuum processed alloys . . . aircraft and missile alloys . . . nuclear steels . . . coated products . . . metallurgically tailored stainless steels. (A-general; ST)

IN THESE COMPETITIVE TIMES, manufacturers of metal products know there's one sure way to get ahead – give the customer more for his money. Consequently the drive is on to make virtually everything smaller, lighter and stronger, thus focusing attention on materials with better strength-to-weight ratios. Titanium and the light metals have been in the limelight owing to the demands from the aircraft and missile industries for light but strong metals. Sometimes overlooked is the fact that steels for everyday uses are making significant gains in many applications at higher strength levels, and further advances are promised.

Releasing the Hidden Strength of Steels

High-strength structural steels (40,000 to 100,000 psi. min. yield strength) are characterized by a considerably higher yield strength than plain carbon structural steels. There are two primary groups: One category consists of the pearlitic structural steels with 45,000 to 50,000 psi. min. yield point as furnished in hot rolled condition. These are known commercially as high-strength steels or as high-strength low-alloy steels, the latter conforming to specifications A.S.T.M. A 242, A 440 and A 441 or S.A.E. 950. There are more than 30 proprietary grades in this category representing almost the entire steel industry. The second category is the heat treated constructional alloy steels which contain somewhat more alloy, with minimum yield strengths of 65,000 to 110,000 psi.

Mechanical properties of the high-strength (or the high-strength low-alloy) types depend on their section thickness. They are not heat treated except as required for cold forming. High properties of heat treated grades depend on quenching and tempering (or precipitation hardening) to develop mechanical properties.

Availability – The high-strength and high-strength low-alloy grades are available in all standard wrought forms – sheet, strip, plate, structural shapes, bars, shapes and special sections. These grades are also supplied as cold rolled sheet and strip in gages down to about 0.028 in. for structures such as trailer bodies or in applications where a good finish is needed on parts to be plated. The heat treated grades are furnished as plates, bars, tubing and sometimes sheets and castings. (Castings of the U.S.S. T-1 analysis became available recently.)

The minimum yield point of structural carbon steel made to A.S.T.M. A 7 is 33,000 psi., while

that of high-strength low-alloy steel is generally 50,000 psi. in thickness of ¾ in. and less. Thus, on the basis of the proportionality of their yield points, the working unit stress in tension employed with high-strength steel may be 1½ times that used with structural carbon steel. However, in members where buckling can occur, the working unit stresses are modified to the extent considered necessary to insure stability. The higher working unit stresses permit reductions in thicknesses of sections in the structure and thus a decrease in weight.

Higher-Strength Carbon Steel – At its annual meeting in June, the American Society for Testing Materials approved specification A 36-60 T for a rolled structural carbon steel of higher yield point (36,000 psi.) than that designated by A.S.T.M. A 7 (33,000). The new specification is a significant step toward potential savings in the heavy construction field. Because A 36 has a higher minimum yield point than present standard carbon structural steels, it ultimately should be used in many structural applications.

Compared to the A 7 and A 373 steels (Table I), the new A 36 structural steel has a minimum yield point of 36,000 psi. When matched against A 7 steel on an equal weight basis, A 36 will withstand about 10% greater load in tension before it reaches its yield point. On the same basis, A 36 steel has about a 12% strength advantage over the weldable A 373 grade. It is reported that A 36 compares favorably with A 373 in weldability. Available forms of new A 36 steel include structural shapes, plates and bars – the same as those rolled to the A 7 and A 373 specifications. The strength-to-cost ratio of the new steel is substantially better than that for other carbon structural steels (Table I) and cost savings should result from its use in bridges, buildings and general construction.

Better Corrosion Resistance – Many of the grades of high-strength steels are also favored by better resistance to atmospheric corrosion, a property which permits the use of thinner sections without the drawback of a shorter life in service. Experience with certain types of high-strength low-alloy steels has shown that when proper paint coatings are used they last 50% longer than when applied to plain carbon steel.

In open exposure it appears that corrosion

Table I – Ratio of Strength-to-Cost for High-Strength Constructional Steels Relative to Carbon Steels

Grade of Steel	A.S.T.M. Designation	Yield Point (Min.)	Cost Per Lb.*	Strength-to-Cost Ratio Relative to A 7 Carbon Steel	
				Tension Members, Short Columns and Beams	Long Columns
Carbon steel for bridges and buildings	A 7	33,000 psi.	6.40¢	1.00	1.00
Carbon structural steel for welding	A 373	32,000	6.60	0.94	0.97
Improved carbon structural steel	A 36	36,000	6.45	1.08	0.99
High-strength steel					
(U.S.S. Man-ten A 440) steel	A 440				
¾ in. and under		50,000	7.4	1.31	0.86
Over ¾ to 1½ in. incl.		46,000	7.4	1.21	0.86
Over 1½ to 4 in. incl.		42,000	7.4	1.10	0.86
High-strength low-alloy steel					
(U.S.S. Tri-ten)	A 441				
¾ in. and under		50,000	8.4	1.15	0.76
Over ¾ to 1½ in. incl.		46,000	8.4	1.06	0.76
Over 1½ to 4 in. incl.		42,000	8.4	0.97	0.76
High-strength low-alloy steel					
(U.S.S. Cor-ten)	A 242†				
½ in. and under		50,000	8.7	1.11	0.75
Over ½ to 1½ in. incl.		47,000	8.7	1.05	0.75
Over 1½ to 3 in. incl.		43,000	8.7	0.96	0.75
Heat treated constructional alloy steel					
(U.S.S. T-1)		100,000	15.5	1.25	0.41

*Price base plus a standard section extra.
†For certain thicknesses.

Source: U. S. Steel Corp.

The editors gratefully acknowledge the help of the following in preparing this article concerning progress in steels:

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Copperweld Steel Co., Warren, Ohio
General Motors Corp., Detroit
Great Lakes Steel Corp., Detroit
International Nickel Co., New York
Jones & Laughlin Steel Corp., Pittsburgh
Lamson & Sessions Co., Cleveland
Latrobe Steel Co., Latrobe, Pa.
Republic Steel Corp., Cleveland
Timken Roller Bearing Co., Canton, Ohio
United States Steel Corp., Pittsburgh
Universal-Cyclops Steel Corp., Bridgeville, Pa.
Vanadium-Alloys Steel Co., Latrobe, Pa.
Washington Steel Corp., Washington, Pa.

stops after the steel has lost about 1 mil of its thickness. The rust coating which forms is dense and adherent. Plans are being made for construction of a commercial building in the Middle West using structural shapes of a corrosion resisting high-strength low-alloy steel which will not be painted.

Economics – Since only moderate amounts of alloying elements are used, the mill price of high-strength steel is about 30% more than that of the cheapest structural carbon steel. Engineers in the structural applications group at U. S. Steel have developed the data in Table I. It compares the strength-to-cost ratio of their high-strength steels, which are typical of many of the products of this type produced by the steel industry, with carbon steels.

However, an understanding of the properties of high-strength steels in relation to design is important if they are to be utilized to the fullest extent. In many instances this means redesign of a product to take advantage of the properties of modern high-strength steels. This action is often sparked by the realization of what can be done with competitive materials such as light metals and plastics in redesigned products.

Where High Strength Pays Off

A large field for high-strength low-alloy steels is in transportation equipment. The railroads have realized substantial economies in operating costs by employing high-strength steels in reduced thicknesses to decrease the dead weight of cars. In some instances, revenues have been increased by enlarging lightweight cars so they can carry additional pay load. Work is under way to lighten freight cars by redesigning underframes, car ends and bodies for high-strength steels.

Cuts Weight – Similar benefits from weight reduction and from increase in capacity are being realized in other mobile equipment – trucks, trailers and buses, for example. A flat-bed trailer was redesigned from a carbon steel structure to one combining a high-strength low-alloy steel with yield point of 50,000 psi. and a heat treated constructional alloy steel (U.S.S. T-1) with a yield point of 100,000 psi. The weight saving of 1500 lb. was the same as that achieved by an advanced design in aluminum.

Manufacturers of tractors and trailers, power shovels, cranes, farm machinery and conveyers are using high-strength steels to build lighter equipment. In bridges weight and cost have been lowered most impressively by using combinations of high-strength low-alloy material and heat treated constructional alloy of 100,000 psi. yield strength based on new design concepts. There is large opportunity for high-strength steels in large structures, such as buildings, bridges, oil tanks, missile handling and launching equipment, earth-moving equipment and other industrial machinery. By using about 3500 lb. of a constructional alloy steel with yield strength of 100,000 psi., an oil drilling rig weighing 3500 lb. less than the conventional carbon steel rig is being built.

Many Uses – Miscellaneous applications for high strength are becoming more diversified each day. A few examples, suggestive of the wide range of uses in which the special properties of these materials are valuable, are crane booms, buckets, bulldozers, derricks, mine cars, lamp posts, pole-line hardware, transmission towers, cable reels, barges and air preheaters.

They are used for automobile jacks, body parts and bumpers. A new approach to a bumper material which is being studied employs an adhesive-bonded, thin-gage stainless sheet as a decorative and protective covering on high-strength steel bumper stock. A heat treated constructional alloy steel (U.S.S. T-1) with yield strength of 100,000 psi. will be used for pressure vessels to hold liquid propellants

New Concepts of Drawability of Steels

*By R. L. WHITELEY and D. J. BLICKWEDE**

RECENT CONCEPTS of sheet steel formability have literally taken on a new dimension. Perhaps because of the predominantly two-dimensional character of sheet steel, little importance has been assigned to the properties of steel in its third (that is, thickness) dimension and how they affect formability. And yet one cannot divorce the influence that these properties have from the over-all plastic behavior of the steel.

Recent studies at Bethlehem Steel Co. have shown that the strength of the sheet steel in its thickness direction is a major factor affecting the formability of the steel in certain types of pressing operations. Generally, the ductility of sheet metal is considered a good indication of its formability. Where the sheet is formed predominantly by stretching (see figure, left), this relationship usually holds true.

There are many forming operations, however, in which the part is formed largely by drawing or upsetting the metal (see figure, right) rather than by stretching. The performance of a metal under these conditions often bears little relation to its ductility in the rolling direction. It is in this class of forming operations where we find that the properties of the sheet in its third dimension are of greatest importance. Best performance during forming is usually obtained when the strength of the sheet is greater in the thickness direction than it is in the plane of the sheet. In other words, sheet steels (or other sheet metals) which are anisotropic in this sense are more suited to deep drawing than sheet with isotropic properties.

Thus, formability depends largely on two characteristics of the steel – its ductility and a distinct anisotropy in the thickness direction. The relative importance of each characteristic depends on the particular operation to which the metal is applied, but neither can be ignored. While in the past much time and effort have been expended to control and improve the duc-

*Bethlehem Steel Co., Bethlehem, Pa.

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at launching sites for the ICBM missiles. Another family of high-strength constructional grades is finding wide application at strength level of 110,000 psi. and at hardness of Brinell 500 for uses requiring abrasion resistance.

Columbium-Treated Steels

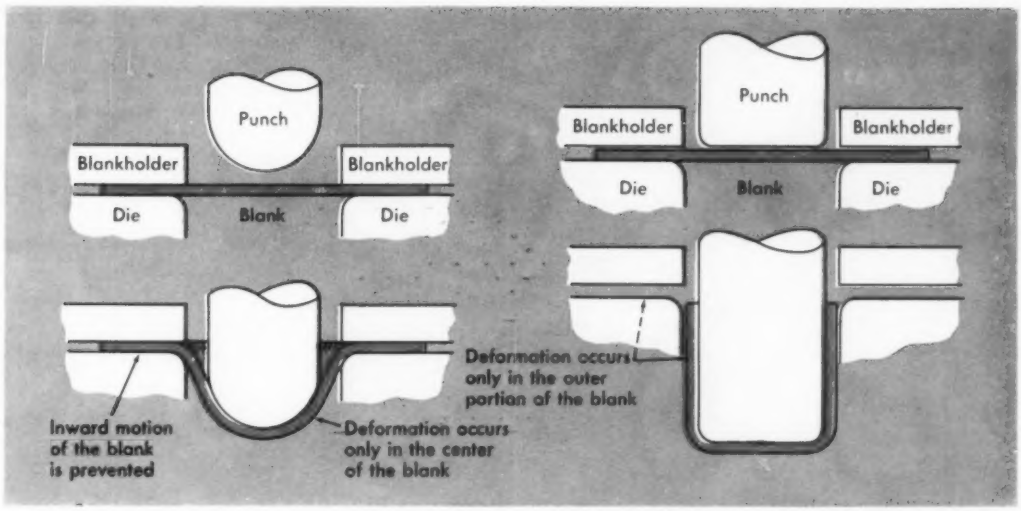
A high level of steel strength in commercial products is being obtained from precisely controlled additions of columbium during the steelmaking process. These are basically semi-killed steels containing 0.01 to 0.04% columbium, developed by National Steel's Great Lakes Steel Div. Columbium decreases the grain size, thereby giving a strengthening and toughening effect without need for raising the carbon content. Since carbon and manganese are low, welding characteristics are good. Columbium also seems to inhibit underbead cracking and to retard the solution of carbides in the heat-affected zone.

A columbium high-strength steel is being used to fabricate a small container (4 in. round, weighing 32 oz.) to dispense oxygen. Pressure on the inner wall of the little tank is 1790 psi. The container is fabricated by joining two halves by hydrogen brazing at 2100° F. which does not reduce the strength of the thin steel.

What the Future Holds

The engineer who learns to design efficiently with high-strength steel will be well equipped to take advantage of future developments in modern steels. Technologists of the steel industry are working hard to develop new steels with higher strength which will be cheap tonnage products and will possess desirable forming and welding properties.

It is expected that, when perfected, these new steels will have yield strengths of 60,000 or 70,000 psi. and perhaps eventually 80,000 to 90,000 psi. as hot rolled. Particular care is being exercised by development engineers working with these new steels to insure that commercial grades possess good weldability and that structures fabricated by welding have the required strength and ductility to withstand the conditions anticipated in service.



Above, Left – Schematic of "Punch-Stretching", a Drawing Operation in Which the Mode of Deformation Is Pure Stretching. Ductility of the sheet is a good measure of its formability

Above, Right – During Deformation by "Die Drawing", Strength of the Sheet in the Direction of Thickness Plays a Predominant Part in Determining Formability of the Steel

tility of sheet steels for forming applications, future work will no doubt consider the anisotropy of the steel as well. With electrical steels, anisotropy has already proven beneficial and has consequently been exploited. It remains to be seen, however, whether a similar development will occur in sheet steels for forming applications.

Also promising are prospects for higher-strength steels of the heat treated constructional alloy type. One group is working to develop a steel of this type which would have 150,000 psi. yield strength for use in structures and pressure vessels where a steel of 100,000 psi. yield strength is now being applied. Here, as with the high-strength low-alloy type, much effort is devoted to developing steels having suitable welding and forming characteristics.

Trends in Carbon and Alloy Steels

In their effort to keep costs in line, technical management is coming to recognize more fully the possibilities of fabricating metal products from leaner alloys and carbon steels. In competitive areas, this trend is pronounced. An excellent example is the hand tool industry where there seems to be a swing to 1045, 5046 and 4063 from 4140, 4150 and 8650.

By using induction hardening, auto makers have been able to switch to carbon steels such as S.A.E. 1037 and 1038 for axle shafts. The trend to cheaper steels has also shown up in auto bumpers. Many are now stamped from fully killed 1008, 1010, 1012 or 1018, if the bumper is more decorative than functional. Use of the carbon grades follows the rule of thumb that if stiffness is adequate, the part will be strong enough.

Residual Elements – The role of residual elements in carbon steels is receiving a great deal of attenion. One reason is that some steel users have been trying to capitalize on the contribution that residuals make to hardenability of plain carbon steels. However, annealing treatments and machinability are affected when residual content is high, and the added hardenability can bring on quench-cracking of through hardening steels or cause excessively high core hardness which results in distortion of case hardened steels. Ultimately, the solution may be to control hardenability as a means of insuring less variation in fabrication and heat treating characteristics from one lot of parts to another. A step in this direction is the establishment of hardenability bands for carbon steels (the culmination of a joint effort between

Fig. 1 – Growing Applications for Leaded Steel in Heavy-Duty Jobs Are Demonstrated by This Gear Being Machined for a Power Shovel at Plant of Thew Shovel Co. This is one of two large rings which support the cab and shovel

the S.A.E. and the A.I.S.I.) which should be available soon.

New H-Steels Added to A.I.S.I. List

Three H-steels, 4520-H, 4718-H and 6118-H, were added to A.I.S.I.'s standard list early this year. They owe much of their extensive use to the automotive industry. All are good carburizing grades. Deeper hardening of 4718-H (Data Sheet, p. 132-B) has made it popular with manufacturers of highly stressed differential ring gears and pinions on trucks and other heavy vehicles. Many passenger-car differential gears and pinions are made from 4520-H (see Data Sheet). The 6118-H grade is being used in steering gears. Its hardenability band will appear in a Data Sheet in the November issue of *Metal Progress*.

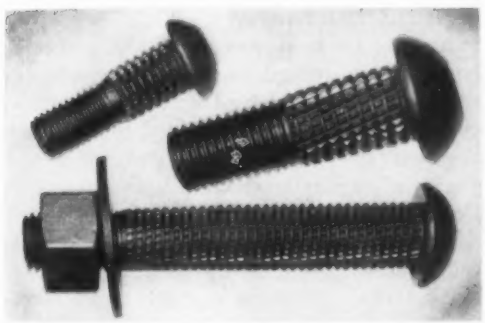
More Applications for Leaded Steel

Although leaded steels have been gaining in popularity because of the economic benefits to be derived from improved machinability, only recently have they been used for open-die forg-

More Parts by Cold Heading

High production rate and close dimensional control are the primary advantages in making the high-strength bearing bolt (below, left) by cold heading. The bolts are formed at high speed in one heading and two rolling operations which knurl the shaft and form the threads. Made of 1038 or 1045 (for diameters above 1⅛ in.), they are heat treated to 125,000 psi. tensile strength (A.S.T.M. A 325).

A more down-to-earth application of cold heading is illustrated by the heel pins shown below, right. These are case hardened after being formed from 1016 steel. First cold headed, pointed and knurled, they are hardened for wear resistance to a depth of about 0.006 to 0.008 in. in a cyanide bath at a temperature of 1600° F. The heel of the shoe is then molded to the head.



ings that weigh in the magnitude of 18 tons. Many circular forged and rolled shapes 145 in. in diameter that are used for hardened gears are now being made from leaded steels.

Use of leaded steels at high strength levels under fatigue and impact loads is still controversial. Some steel producers recommend that these applications be avoided, especially if the steel is to be heat treated to its maximum strength level or subjected to impact loads. However, extensive research (see "An Investigation of the Fatigue Characteristics of Leaded Alloy Steels", U. S. Dept. of Commerce, Office of Technical Services, PB-121834) has established that lead additions have no tangible influence on mechanical properties at normal service temperatures. Furthermore, experience has shown that lead in steel is not as detrimental to weldability as the high sulphur contents normally found in free-machining grades. (More will appear about this aspect in a forthcoming issue of *Metal Progress.*)

Leaded Alloys – The use of leaded alloys is increasing. Such grades as 5140 and 4140 for auto parts and hydraulic system components which are subject to low loads or pressures are good examples. Worm gears for steering mechanisms which cannot be extruded because of their shape are another application.

Lead additions to low-alloy grades such as 4140, 4340 and 8630 reduce machining costs of forgings that have been heat treated to high hardness levels required for gears (Fig. 1), bearing surfaces, turret rings and other products exposed to wear or abrasion. Improvement in tool life up to 600% and reduction in machining time of over 50% are not uncommon.

According to R. W. Bennett, chief metallurgical engineer, Alco Products, "The actual limitation for machining cost improvement is generally a function of the capacity and condition of the machining facilities, the geometry of the product and the machining requirements." An added bonus is the excellent surface finish which results from normal machining of leaded steels.

Cold Extrusion Gains

Cold extrusion of bar or wire in presses or multistage headers continues to make progress at the expense of screw machine methods. Most of the starting material for cold extrusion is

fine-grained plain carbon steel, generally in the form of annealed coiled bar or wire. With intermediate anneals and stress-relief, a wide range of carbon and alloy grades can be cold extruded. Full aluminum-killed C 1008, C 1020, C 1024, C 1030 with low silicon are representative. Alloy steels such as 4023, 4130, 5120, 5130, 8620 and 8630 have also been cold extruded. Mild preheating (warming to perhaps 250° F. by induction or otherwise) just prior to heading is a great help.

Tool design plays an important part in determining the quality of steel needed. As long as metal is kept under compression during extrusion, as in current die designs, it will tend to close rather than open at surface defects.

Because the surface of the rod or wire is extremely important in cold extrusion, steel makers are aiming at better quality control in the mill. At least one mill inspects all billets by Magnaglo. Depth of seams which are revealed can be estimated to within ±0.005 in. from surface indications alone. The billet can be diverted from the bar mill or reconditioned if seams are too deep.

New Family of Nickel Steels

A series of nickel-iron alloys containing from 18 to 27% nickel is being evaluated at International Nickel's Bayonne Research Laboratory. Invented by C. G. Bieber, Inco metallurgist, the steels respond to precipitation and transformation hardening without the need for quenching. Carbon is kept below 0.05% and titanium (1.7%) and aluminum (0.2%) are added to obtain hardening by precipitation. About 0.4% columbium is also present.

Two promising alloys in the series contain 20% and 25% nickel. With 20% nickel, transformation from austenite occurs on air cooling from a solution annealing temperature of about 1500° F. Aging is done at 850 to 1000° F. Strengths on the order of 270,000 psi. yield and 280,000 psi. tensile with 12% elongation are obtained. The 25% nickel composition can be annealed to lower hardness but requires an intermediate treatment at 1300° F. before aging at 850 to 950° F. With this heat treatment, it develops 252,000 psi. yield and 277,000 ultimate.

Both alloys have excellent cold working characteristics. In one instance the 20% nickel steel, cold worked from an annealed condition (Rockwell C-36), hardened only to Rockwell C-37 after 70% reduction. (More information on progress with these alloys will appear in *Metal Progress* next month.)

Vacuum Processed Steels

Vacuum degassing (steel is melted in air and then poured in a vacuum tank) is particularly well adapted for use in the production of heavy steel forgings requiring very large ingots. It is being used to make cleaner and sounder steel for hardened rolls at no increase in cost to the user over air-melted grades.

Since there is no practical limit to the quantity of steel which can be handled by vacuum degassing, the future may see it used extensively to improve the quality of H-11, 4340 and other types of high-strength toolsteels. According to Elliott A. Reid, Bethlehem Steel's assistant chief metallurgist, "It is not expected that vacuum degassed steel will entirely equal the high quality of vacuum melted steels in all respects. However, its greatly improved quality should be satisfactory for many applications where vacuum melted steel is now used. Under these circumstances, the lower cost and high production potential of vacuum degassed steel will be most attractive."

Larger Ingots – In vacuum melting the trend appears to be toward larger ingots made by the consumable electrode arc process using air-melted electrodes. Most demand has been for 20 or 26-in. diameter ingots weighing from 5000 to about 19,000 lb. However, a larger size, 40 to 50 in. in diameter and 50,000 to 60,000 lb., will soon be available from Allegheny Ludlum.

Through consumable electrode and induction vacuum melting, much cleaner steels such as 52100, 8620, 6150, 9312, A 286, Waspaloy and 300-M are available. Most are still for aircraft and missile uses. In the November and December issues *Metal Progress* will present an evaluation of 4340 in bar and sheet form, originating as basic electric, induction melted and cast in vacuum, and as consumable electrode.

Type 4340 for Aircraft Forgings

For aircraft landing gears, S.A.E. 4340, (both regular and modified) continues to be the mainstay. The trend is toward an ultimate tensile strength of 260,000 to 280,000 psi. because of greater loads and less space in the aircraft in which to tuck the landing gear. With careful melting procedures, 4340 of satisfactory cleanliness to meet 6% minimum and 10% average transverse reduction in area in forgings is

produced in electric furnaces. But care must also be used in design and fabrication.

In landing gears, stress-raisers such as tool marks, drastic change in section size, sharp edges and small radii must be avoided. Where possible, the steel is protected from corrosion by painting or plating or both. Navy specifications, however, do not permit plating of landing gears because of danger of hydrogen embrittlement.

Need for Greater Strength – In their search for superstrength steels which can be treated to higher strength levels than 260,000 to 280,000 psi., some feel that the H-11 toolsteel offers the most immediate potential. It is strong (280,000 to 300,000 psi. is possible) and maintains its load-carrying ability to about 1000° F. At the present time vacuum melting is necessary for proper transverse ductility in large forgings.

For some parts, such as the landing gear of large aircraft being contemplated or in the initial production stage, the problem is to obtain ingots which are large enough to permit adequate hot working so that transverse properties will be satisfactory. Forging stock up to 24 in. (round-cornered squares) are being produced today from 26-in. and 32-in. ingots, the maximum sizes available for vacuum melted steel. Improvements in melting procedures, thermal treatments and in the size of forging stock can be expected since H-11 will represent a large proportion of the total toolsteel output.

New Series of Nuclear Steels

A new series of steels has been developed by Jones and Laughlin Steel Co. for use in components of nuclear power plants. The chemistry of these new steels is different from that of standard grades of carbon steel in that manganese and cobalt contents are reduced to an extremely low level. The steels were developed to help solve one of the problems in maintenance of nuclear reactor equipment; that is, the retained radioactivity caused by the reaction of thermal neutrons with manganese prevents repair and adjustment of equipment.

Other Uses – Although the steel was designed specifically for the nuclear industry, it is characterized by a high degree of cold plasticity. It also has good impact properties at low temperature. Thus, it is expected that other commercial possibilities will be found in cold extruded shapes, cold heading, electronic parts, and in the aircraft and missile industries.

Fig. 2 – Axle Beam for Landing Gear of Jet Airliner Is Machined From 4340 Steel Which Meets Special Aircraft Specifications Concerning Transverse Properties. This landing gear component is treated to 260,000 to 280,000 psi. ultimate tensile strength (Rockwell C-50 to 53) in an atmosphere to minimize decarburization

Auto Makers Turn to Galvanized Sheet

Zinc-coated steel for auto bodies holds great promise in coping with corrosion. Although sheet which is coated only on one side can be obtained now, steel mills are not yet ready to produce it in the quantities or zinc thicknesses which are needed. Zinc-coated sheet will probably be limited to unexposed panels because

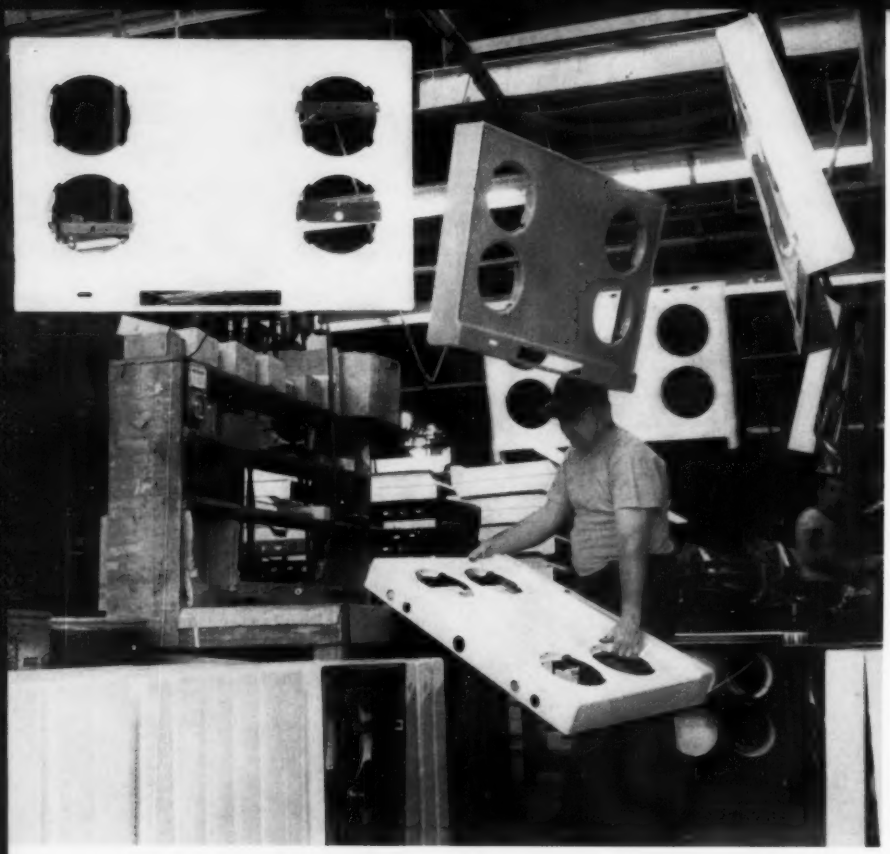


Fig. 3 – New Steels With Very Low Carbon Offer Excellent Enameling Properties in the Standard Two-Coat Process With Good Results for Single "Direct-On" Cover Coatings, Too

the roughness of the coating tends to be transferred to the other side during forming.

There has been limited use of differential-coated sheet in a few of this year's automobiles. Some difficulty has been experienced in preparing the zinc surface for painting. An acid dip or wipe, sometimes by hand, has been necessary.

Welding Problem – Weldability of galvanized sheet is a problem. Zinc is driven away from beneath spot welds, thus leaving potential points for corrosion. From the viewpoint of the production engineer, zinc-coated steels also introduce another complication. In welding shops it will be necessary to install ventilating equipment to get rid of the zinc fumes. This is an expensive proposition for the auto industry. Still another problem is that zinc builds up on the electrodes of high-speed spot welders at such a high rate that the electrodes must be reground more often than when uncoated steel is used.

Even with these problems, zinc-coated steels – either differentially coated or applied only on one side – will be used more in next year's automobiles. Probably all the rocker panels in the 1961 models will be zinc coated. This panel is one of the first to show the ravages of corrosion which is accelerated by increased use of salt on highways and by the thinner steel used.

Aluminum-coated steels also show promise. Problems are very similar to those encountered with zinc but protection in some uses appears to be greater. Tail pipes protected with a coating of aluminum, for example, outlast their zinc-coated counterparts by about 4 to 1.

Vinyl-Coated Steels

Since its introduction a few years ago, vinyl-coated steel has taken an important role in applications for prefinished sheet. Made either by laminating or by rolling on a liquid plastisol, vinyl-coated steel possesses functional and decorative qualities which are attractive for products requiring durable finishes. Virtually any texture or design can be reproduced in a vinyl coating. This means more versatility in providing attractive exteriors for appliances such as TV cabinets, air conditioner exteriors, thermos jugs, picnic cans, and business machines.

Auto makers are using vinyl-coated steel for interior automobile applications such as instrument panels, glove compartment doors and other interior decorative panels. A big advantage of vinyl-coated steel is that it is easy to give a product a face-lifting without changing dies, by using a different texture or design.

*Advances in Stainless Steels**

A GREAT DEAL of progress is being made in the effective use of stainless steel by the transportation, aerospace and nuclear power industries. The City of Philadelphia is replacing an entire fleet of subway cars with vehicles made of stainless (Fig. 4). Totaling hundreds of subway cars, and involving $25,000,000, these vehicles are largely austenitic stainless steel. Each car contains more than 9000 lb. of austenitic stainless. Almost all of it is corrugated sheet less than 0.090 in. thick which is spot welded into a unit body. The underlying structural frame is also fabricated from stainless steel.

*This section was prepared in cooperation with the Committee of Stainless Steel Producers of the American Iron and Steel Institute, Richard E. Paret, secretary.

High-Temperature Alloys

Stainless steels, particularly the austenitic "hardenable" alloys, are finding acceptance among designers working at strength levels as high as 225,000 psi. and temperatures from 1000 to 1500° F. Forming and welding these steels

Fig. 4 — Use of Stainless Steel in 270 Cars for Philadelphia's Subway System Is Expected to Bring Savings in Operation and Maintenance Costs of $6,500,000 During Their Life Span. Being built by Budd Co., each car is designed as a girder with the roof and floor as chord members connected by the sides which join the entire car cross section into a load-carrying beam. Primary structural members are austenitic stainless ranging in thickness from 0.016 in. for roof corrugations to ⅝ in. for reinforcing gussets at the doors

is done in a ductile austenitic condition, followed by appropriate heat treatment to produce the required combination of properties in the completed weldment.

Work in this area is continuing in an effort to produce steels with strengths from 350,000 to 500,000 psi. by better control of the metallurgical structure. Such high tensile strengths will involve relatively low tempering temperatures; hence a loss in strength will occur during sustained exposure to higher temperatures. But stainless alloys with strengths approaching 500,000 psi. may be feasible for short-time exposure at temperatures up to 1200° F.

Bearing Alloys – High-strength hardenable stainless steels, based on the A.I.S.I. 400 series, possess relatively high creep strength at elevated temperature. Modified martensitic stainless alloys, such as Type 440-C, have proved suitable as bearing steels up to 900° F. Tests extending beyond 500 hr. indicate good dimensional stability, adequate temper resistance (600 to 900° F.), high initial hardness, and good corrosion resistance.

One bearing alloy is basically Type 440-C stainless, modified with vanadium, tungsten, molybdenum and cobalt. The alloy is heat treated at 2200° F., oil quenched, and refrigerated at −105° F. Tempering the steel at 1000° F., with intermediate subzero cooling after the first and second draws, results in a hardness of Rockwell C-66. After 500 hr. at 900° F., surface hardness drops to Rockwell C-65. In a water-vapor corrosion test, the bearing surface pitted only slightly more than annealed Type 430 stainless steel bearings.

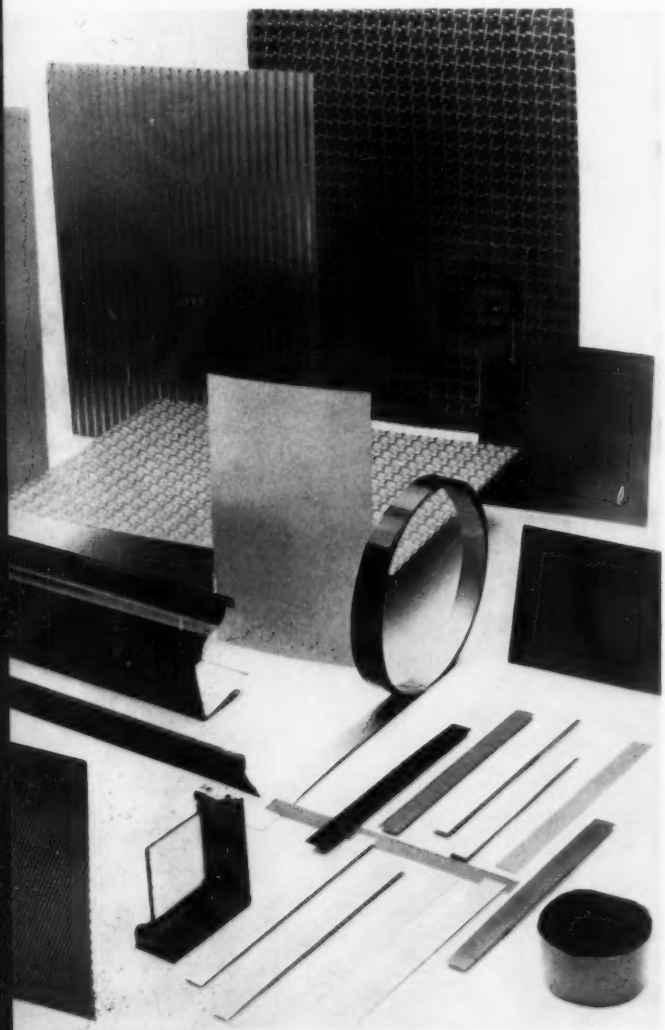


Fig. 5 – Organic Coatings Give Stainless Steel New Versatility. Available in 11 colors in sheet and coil form up to 48 in. wide (mostly in Types 302 and 430), the sheet can be sheared, bent, formed and drawn without damage to the coating. Although developed primarily for architectural use, it is being considered for refrigerator trim, mixing bowls and signs

Phosphorus Increases Rupture Strength

Development of a modified form of Type 316-L austenitic stainless is to be announced this fall. The alloy contains over 0.3% phosphorus. Standard Type 316-L contains a maximum of 0.045%. It is claimed that increased phosphorus content can impart greater rupture strength at elevated temperatures. Phosphorus is normally considered objectionable in stainless alloys because of its adverse influence on welding properties. Restricting carbon content below 0.03%, however, enables retention of weldability comparable with that of normal Type 316.

Improved high-temperature strength of the modified Type 316-L stainless should encourage its use in many elevated-temperature areas, such as thick piping in the power field. Room-temperature properties of the modified Type 316-L resemble the basic alloy and include good hot and cold forming characteristics.

Cause of Hot Cracking Revealed

In stainless and other steels, elements like titanium and columbium have been added to

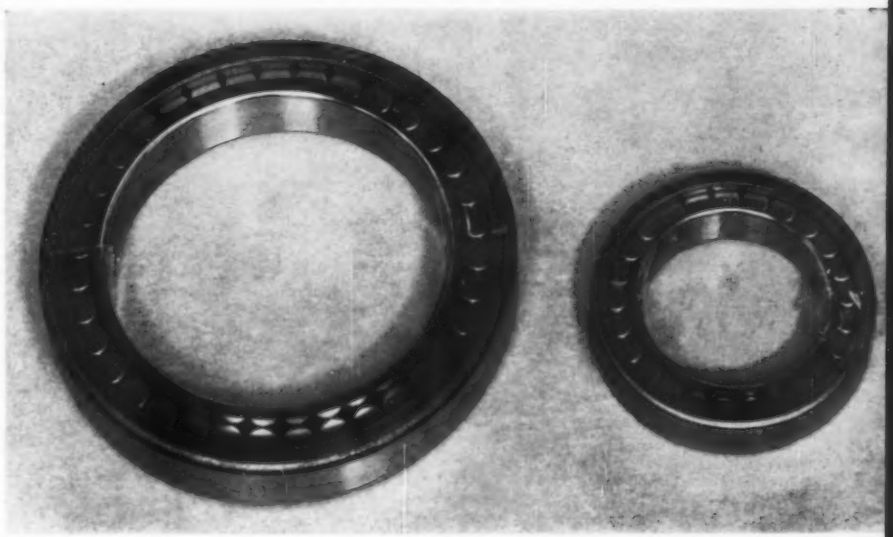


Fig. 6 – Bearings Made of a Modified Type 440-C Stainless Steel Are Used in the Thrust Reverser Assemblies in Boeing 707 and 720. When the thrust reversers are being used, the bearings take a compressive stress of more than 600,000 psi. at temperatures up to 800° F. Tests show that the alloy (vacuum melted for this application) experiences only an 8% drop in hardness when exposed for 400 hr. at 900° F.

increase strength at elevated temperatures. Occasional hot cracking of Types 321 and 347 stainless elbows and flanges in steam and nuclear power plant applications now has an explanation: Both titanium and columbium are particularly active in increasing hot cracking susceptibility.

Tantalum is as effective as columbium in stabilizing carbides and in increasing creep strength, but does not increase hot cracking susceptibility nearly as much as columbium. Tantalum-stabilized stainless alloys should possess most of the attributes of columbium-stabilized plus greatly improved resistance to cracking. (It has been widely used in England for decades.)

Disadvantages – Whether this alloy modification will effectively replace Types 321 and 347 remains a question. Tantalum-stabilized stainless does have some disadvantages. It exhibits a higher neutron absorption cross section than Type 321 and may therefore find few applications in nuclear reactors. Further, tantalum costs more than columbium and much of it can be lost during melting and welding.

Stainless for Low-Temperature Use

Chromium-nickel stainless steels are inherently suitable for service at temperatures of −300 to −425° F. Recently completed impact and tension tests on austenitic stainless steels show that the annealed stainless alloys retain excellent impact values at temperatures as low as −425° F. Chemical composition, specimen geometry, section size, and grain orientation have no serious effect on impact properties. Good impact strength is retained after prolonged low-temperature exposure. One field report reveals that after 15 years' exposure to liquid oxygen the impact strength of a Type 303 valve stem was 25 ft-lb. at −295° F., well above the minimum of 15 ft-lb. called for in A.S.T.M. specification A 300.

D-319 and Type 316 Interchangeable

Stainless steel alloy D-319, modified from A.I.S.I. Type 316, can now be used interchangeably with Type 316 under all rules applicable to the latter alloy, according to Special Ruling Case No. 1254 by the Boiler and Pressure Vessel Committee of the American Society of Mechanical Engineers. Corrosion resistance of D-319, particularly against pitting, is said to be better than Type 316.

Marine Atmospheres – Austenitic "hardenable" stainless steels resist corrosion better in marine and mild industrial atmospheres than standard hardenable chromium stainless alloys. Fully hardened Type 301, in the same corrosion tests, retained its original appearance better than the austenitic "hardenable" alloys, which in turn appeared in better condition than martensitic alloys.

Much progress is being made in methods for fabricating stainless steel parts and in applications for prealloyed stainless powders and for cast stainless alloys. These subjects will be covered in future issues of *Metal Progress*.

Technical Management at Work – Pre-production planning in stamping plant brings together members of Budd Co.'s technical management team. Tackling the problem of forming an automotive part are P. G. Nelson (seated right), superintendent, production laboratory, Walter Bradhering, staff manager, Automotive Div., J. B. Davis, Jr., assistant superintendent, die engineering, J. H. Zeder, Jr. (pointing), superintendent, die engineering and E. H. Tomaselli, supervisor, metal specifications. Briefed on expected problems in metal selection, forming severity and quality control, the team can lay the base for a better product at lower cost.

A Report to
Technical Management

Progress in Forming Steels . .

How to Make Better Drawings and Stampings

*By PAUL G. NELSON**

What forming techniques are best, how can all of the grades of sheet steel be used most economically and how can stamping severity of a part be estimated before production starts? This article answers these important questions as applied to steel forming and discusses steps toward lower production costs. (G3, G4, Q23q; CN, 4-53)

METALLURGICAL DEVELOPMENTS of the more glamorous metals often obscure the great importance of low-carbon steels in our economy. Nevertheless, the use of low-carbon sheet steel continues to increase. Although metallurgical improvements have not been as spectacular as with other metals, advances have been made in improving production so that enormous quantities of sheet steel can be produced at relatively low cost. Surface quality of killed steels is much better than it was ten years ago. However, it must seem to the metal fabricator that only halting advances in forming quality have been made. Aging is still being blamed for poor performance, and today's hot rolled product does not equal the performance of normalized sheets of 25 years ago.

During the thirties, the formability of steels was improved to keep pace with the growing complexity of stampings, particularly for the auto industry; cold rolled sheets and deep drawing killed steels were outstanding developments. The ultimate in formability was probably attained with sheet-annealed killed steels in 1950.

In the last decade, the tool designer has had to resort to increased ingenuity to produce the stampings which are found on the streamlined cars of today. Not only must the stamper be able to make difficult parts, but he must also cut every possible corner to reduce costs. Many times the margin of profit may be the inch or two of metal that he can save on a blank. To produce these stampings the proper choice of tooling methods and material must be made.

*Superintendent, Production Laboratory, Budd Co., Philadelphia.

Selecting Forming Method

The principal types of stamping machines are hammers, hydraulic presses, and mechanical presses. Hammers, which were first available, are still used for making parts in small quantities. Hydraulic presses vary in size from ¾ to 15,000 tons. They have longer operating strokes than mechanical presses, operate at full rated capacity over the entire length of stroke, and their speed can be varied. Frequently certain difficult forming operations can be performed by programing the speed of the stroke. On the other hand, mechanical presses are usually faster. Hydraulic presses usually are either single or double action; mechanical presses may be single, double, or triple action, depending on the number of moving rams.

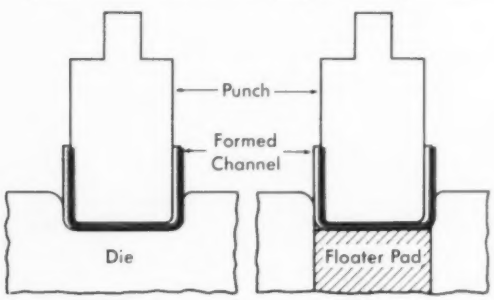
Single-Action Dies

Stampings can be made by a variety of methods. The most elementary design employs a single-action die which consists in the simplest form of a punch and lower die (Fig. 1, left). This type of stamping can be made from a small, low-cost, pre-developed blank. By careful meshing of blanks and by use of coils instead of sheets, scrap losses can be held to a minimum. Dies of this type, which are used to form simple straight flanges, are commonly termed brake dies. Similar dies, however, are also used to form parts with curved flanges. The curved flanges may be either shrink or stretch flanges.

Frequently, the addition of a floater pad to a single action die will permit forming of more difficult parts from a pre-developed blank. This arrangement (Fig. 1, right) is frequently used to form channel or hat-shaped parts such as automotive chassis side rails and cross members.

The single action can also be modified with a local hold-down or baffle plate on one part of the die. This modification introduces the double-action principle and permits forming of more complex parts. The larger blank and more expensive die required for double-action forming are not needed.

Fig. 1 — Simplest Forming Method Consists of Single-Action Punch and Die Arrangement. Floater pad (right) permits more difficult parts to be formed by supporting more complicated web shapes while flanges are being formed. Actually, the web is formed first between punch and floater and then as floater pad pressure is overcome, flanges are formed



Double-Action Dies

For more complex parts, such as automobile doors, fenders and roofs, double-action dies are required. These dies consist of a punch which is usually the master shape, a lower die also known as the lower ring or lower blankholder, and upper ring or blankholder. In operation, the steel sheet or blank is held between the upper and lower blankholders while it is formed by the punch.

Holding pressure can be applied to the blankholders with springs, an air cushion, or by a second action of the press. In some dies the lower blankholder may consist of two parts — the blankholder proper and a floater which helps support the blank while it is being formed. The floater may be actuated by springs, an air cushion, or an additional action of the press.

Although only rarely required, dies and presses with a triple action are sometimes used for certain types of stampings. In this type of die, the punch forms the part first and then dwells while a third action forms other parts of the stamping.

Blankholder Design Still an Art

Designing blankholders for double and triple-action dies is an extremely important part of die building. Properly designed, a blankholder decreases stamping severity, reduces scrap losses, and produces parts which have good surface and dimensional accuracy.

Unfortunately, there is much cut and try in the development of blankholder shapes. It would seem possible for some shape determinations to be made by scientific calculation, but thus far it is largely an art. The machinist or toolmaker who works inside the die with grinder and stone is aptly named a tryout man. Good tryout men are probably scarcer than good engineers.

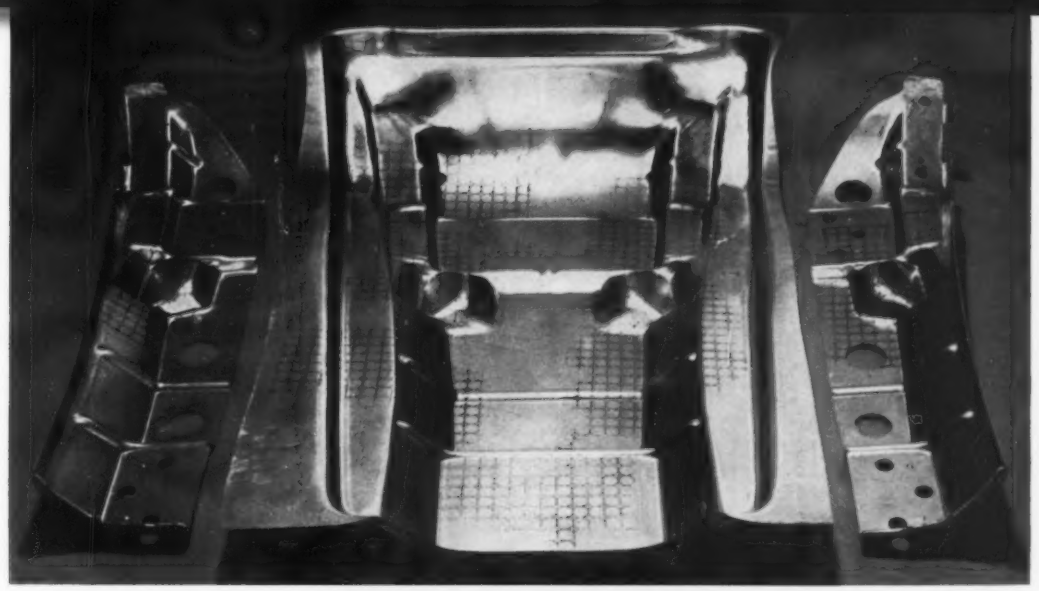


Fig. 2 – Combination of Two Stampings (Left and Right) Into One (Center) Reduces Scrap Caused by Blankholder Markings. Instead of four strips of scrap which result when two smaller stampings are made (shown here in trimmed condition), the larger stamping (in as-formed condition) has only two edges and a small center area which need be trimmed off

Fig. 3 – Raised Bead at Inside Edge of Blankholder Locks Sheet During Forming and Results in Lower Scrap Losses

In any double-action stamping, there are losses where the sheet is gripped and marked by the blankholder. These losses can be minimized in several ways. In one method, a right and a left-hand stamping may be combined so as to limit the blankholder scrap to one side of the stamping as in Fig. 2. In another approach (Fig. 3) the inside perimeter of the blankholder has a raised bead which exerts considerable holding force with only a little of the blank covering it. This method of holding is particularly suitable where the stamping is a shallow form because the required stretch or elongation in the stamping is minimized. It is not as satisfactory for deep-formed parts or parts that are quite flat in shape.

Sheared Blanks Reduce Costs

Another important consideration in double-action forming is that by modifying the shape of the blankholder it may be possible to use a sheared rather than a die-cut blank. If blanks can be sheared, it is not necessary to build blanking dies. Also, there are possible metal savings where blanks can be sheared from coils.

Choosing the Correct Grade of Steel

Proper selection of sheet steel will permit the use of the cheapest possible grade with minimum scrap losses. With present trends in mechanization and automation, material variations cause more loss of production time than before. Automatic devices often interfere with removal of scrap and make die maintenance, blank and die lubrication and press adjustment more difficult. Variations in hardness, thickness, and surface are to be expected in sheet steel. However, when material variations are compounded by all factors varying in one direction, adjustments are extremely difficult. A typical example of this would be the compari-

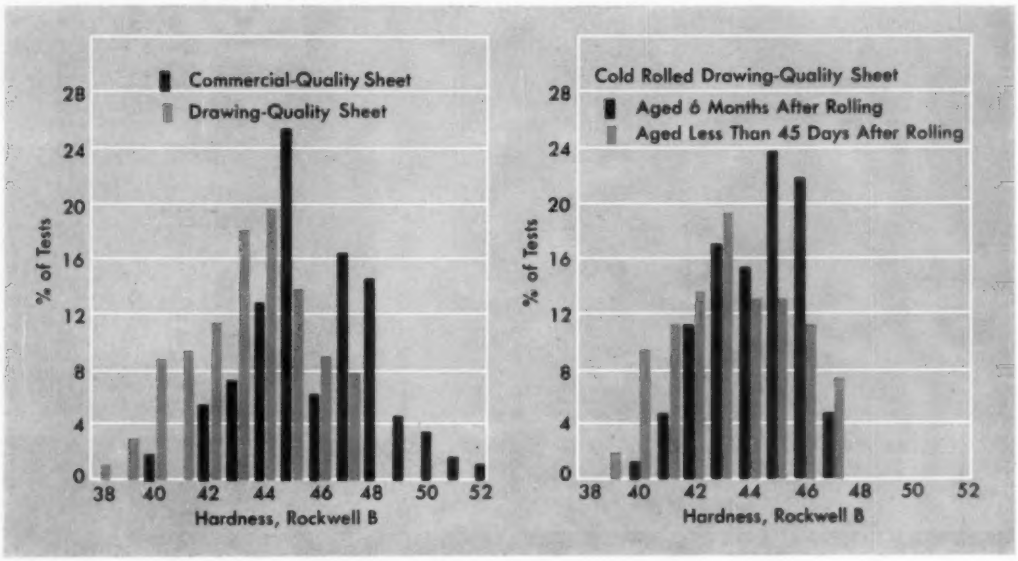


Fig. 4 – Variation in Hardness of Part Made From Cold Rolled Commercial-Quality and Drawing Quality Sheet. The latter grade is more uniform and therefore more expensive. Data were taken from over 100 tests on each grade

Fig. 5 – Effect of Aging on Hardness of Cold Rolled Drawing-Quality Steel. Changes were minor in these instances and did not have a pronounced effect on formability

son between a hard, smooth, thin sheet and a rough, soft, heavy sheet. Each characteristic might be within acceptable mill standards, but the press and die would need adjustment in an entirely different way for each one.

Characteristics of Sheet Steel

Low-carbon sheet steel is available as commercial-quality rimmed steel (the cheapest), drawing-quality rimmed steel (intermediate in cost) and drawing-quality aluminum-killed steel (the highest priced). All of these grades are available in either hot or cold rolled finishes. This article will be confined to the cold rolled product.

Cold rolled sheets are available either as dead soft, sometimes called annealed last, or as temper passed. Full temper-passed sheet is required for exposed parts such as automotive fenders, hoods and doors, refrigerator doors and washer and dryer cabinets where stretcher strain markings cannot be tolerated. Dead soft sheet is preferred because of higher ductility in all grades and less tendency to strain age in rimmed steel grades.

Annealed rimmed steel will strain age to varying degrees after cold work, thus reducing its ductility and raising its hardness and yield point. Before sheet annealing was discarded by the principal mills in favor of coil annealing, true nonaging rimmed steel was produced in the annealed-last condition. Today, the cold work which is required to flatten annealed coils will induce some aging even in the dead soft grade. Unless temper mill operators are careful, the reduction given to so-called dead soft steel may be little different from that given to the regular temper-passed sheet.

Commercial-quality sheet steel (CQ) as produced by normal commercial practices can be expected to have fairly good formability. However, there are no guarantees of performance or mechanical properties except that the sheet will pass a flat bend test and normally not exceed Rockwell B-60.

Actually these are not guarantees at all because poor materials can often pass the tests. Fortunately, the mills do in most instances supply much better steel than is indicated by this loose specification. Fig. 4 shows quality variation obtained on a typical CQ part.

It must be recognized that the use of CQ steel still entails some risk and for this reason it is unacceptable for parts with moderately severe surface conditions. Material of the poorest quality which might be received may be unsatisfactory for the intended part, and the

mill will not usually assume responsibility. Mills do not accept responsibility for internal defects which show up after forming. So-called "ghost lines" are frequently revealed on formed parts made from rimmed steels after stamping.

Drawing-quality rimmed steel (DQ) is produced for parts that would normally be considered too difficult to stamp from commercial quality. In many instances the drawing quality is little different from commercial quality, but the variations are held within closer limits (Fig. 4). For this you must pay a higher price.

But you can still get into trouble with DQ steel because of aging, poor mechanical properties and breaks during stamping. An example of how DQ will age is shown in the histogram in Fig. 5 which reveals variation in hardness of steel that was over six months old compared with steel which was less than 45 days old. It will be noted that only minor changes in hardness which normally would not markedly affect formability have occurred in the period from 45 days to six months. These steels formed satisfactorily on the same parts.

If the over-all scrap losses do not exceed the scrap allowable percentage, the mills usually bear no responsibility for the poor scrap performance of individual lifts of admittedly bad material. Steel producers, however, do accept responsibility for defects which are revealed after forming.

Aluminum-killed steel, properly made, will not strain age or show stretcher strains in formed parts if it is sufficiently temper rolled. Its average formability is superior to rimmed steel and for this reason it is used on the most difficult parts or for blanks that cannot be roller leveled prior to forming. Unlike rimmed grades, killed steel for exposed parts normally does not require roller leveling before being formed. However, nontemper-passed steel such as the dead soft grade does show stretcher strains. Because adequate temper rolling will prevent this condition, the steel producers will make amends when it is encountered.

Aging in Low-Carbon Steel

As mentioned before, low-carbon rimming steel is subject to age hardening. One type of age hardening, called quench aging, occurs when low-carbon steels are quenched from temperatures of 1000° F. and above. A fairly well understood process, it results from precipitation of iron carbide from ferrite. Fortunately, quench aging is usually no problem in forming operations. Cold rolled rimming grades which are annealed also harden by strain aging after they are subsequently cold worked. This form of age hardening increases hardness and reduces the formability of the steel.

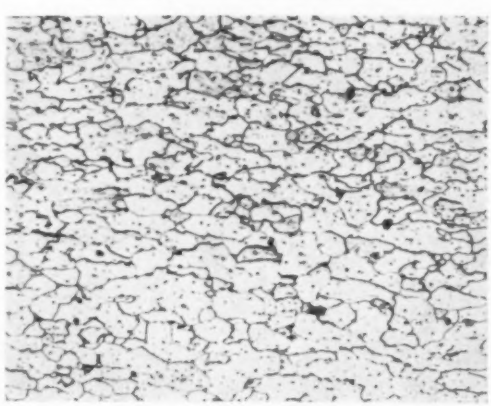
Heats of steel vary considerably in the extent to which they age. Many variables in steel mill manufacturing affect aging rates, but grain size, nitrogen content, degree of temper rolling, temperature of temper pass, and temperatures encountered during shipment and in the customer's plant are certainly important. Aging occurs rapidly and most of the changes in mechanical properties of the steel can be observed in less than 60 days.

Because aging adversely affects forming properties, it is often blamed for formability problems. However, it is also true that properly made rimmed steel usually has good forming properties after extended periods of time. This is indicated in Fig. 5. Although the cold rolled, drawing-quality steel has been aged for six months, it still retains good formability.

Aluminum Prevents Aging

To overcome the problems of strain aging, aluminum-killed and vanadium-treated rimmed steels have been developed. Aluminum-killed steels are completely deoxidized with aluminum, and, in addition, enough is added to give a residual metallic aluminum content of 0.02 to 0.06%. Properly made aluminum-killed steels do not change in mechanical properties because of strain aging. Sheets are also much

Fig. 6 – For Best Forming Properties, Aluminum-Killed Steel Should Have Elongated Grain as Shown Here



more uniform in hardness from edge to edge as compared to rimmed steel.

The most desirable microstructure for killed steel is an elongated grain as shown in Fig. 6. To obtain this preferred microstructure, the analysis of the steel and its processing, such as finishing and coiling temperatures and annealing cycles, must be carefully controlled. The full effects of the elongated grain structure have never been completely explained. Compared to rimmed steel, the aluminum-killed grade usually has a lower yield point, higher uniform elongation and higher over-all elongation. It seems likely that the anisotropy or preferred orientation of this grade also plays an important part in its superior forming quality.

Vanadium-treated steel is a rimmed grade and was developed as a nonaging steel to overcome the surface problems and poor yield which are encountered in killed steel. Because many of the mills have made great progress in overcoming the surface problems of killed steel, the use of vanadium steels has been limited.

At the present time, killed steels represent the ultimate in formability of low-carbon sheet steels. They were developed about 25 years ago, and, except for improvements in surface (accompanied by a loss in over-all formability), have not been changed much since that time. They cost more than the rimmed grades, but in many instances this extra cost is more than offset by better performance. It seems unlikely that the low-carbon steel user can expect any radical improvements to be made in this grade in the near future.

How to Rate Stamping Severity

Selection of the most economical steel is based on ratings of parts which are established by personal observation of drawings, stampings, models and plaster casts, strain measurements on formed stampings and tryout of steel of varying quality on the part. Preliminary estimates of severity are made by the first method so that steel can be purchased in advance of actual production.

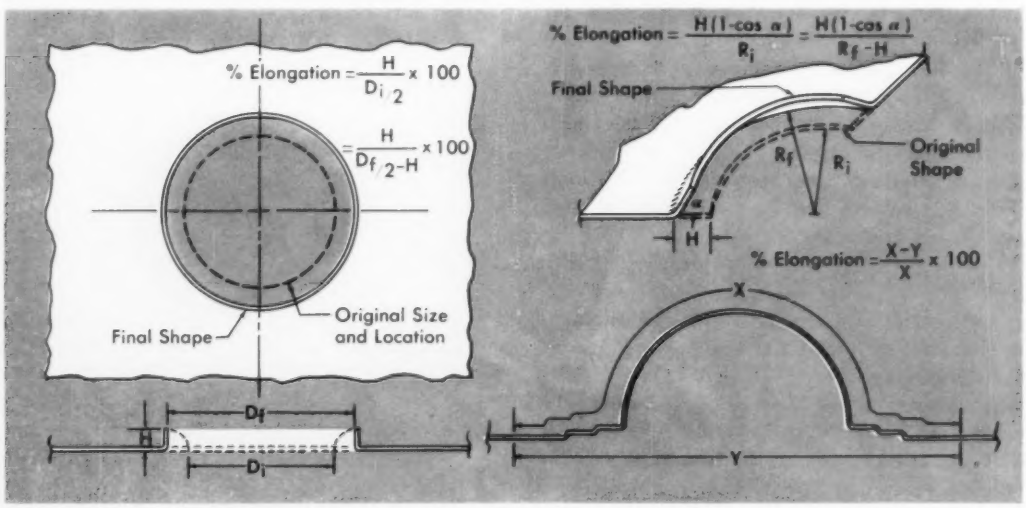
Because many parts are formed by a combination of several types of deformation, it is frequently difficult to differentiate them completely. The most important consideration, however, is usually the expected maximum elongation in the part. Mathematical analyses of expected elongations in parts can be made for some conditions such as flanged holes, stretch flanges, and formed pockets. Examples are given in Fig. 7. These calculations can be made from the part drawing.

Cheaper Grades May Be Satisfactory

Plaster casts of lower dies and models of punches may also be used to calculate expected elongations in any one operation. Some studies not only aid in material selection, but indicate blank sizes and die changes needed to bring expected elongation within reasonable limits.

These calculations are not always as precise as desired, but they do help greatly in making

Fig. 7 – Examples of How Drawing of Part Can Be Used to Estimate Expected Maximum Elongation of Metal During Forming



estimates. As might be expected, they should be conservative estimates except where competition requires them to be as accurate as possible. It can be very embarrassing to a purchasing department to find in the tryout stage that a better, more costly steel is needed than that already purchased for the initial run.

Strain Measurements Help

During the tryout stage, it is possible to make strain measurements on formed stampings. Usually a ruled grid is applied to a blank either by scribing or with an inked rubber stamp. This blank is then run through the various forming operations and strain measurements are made after each operation (Fig. 8). Tentative ratings are based on the maximum strain or elongation measurements.

When a final stamping which meets inspection requirements is obtained, it is possible to try steel of lower quality. To obtain maximum information from these tryouts, the blanks should be ruled with grids. After forming, the grids should be studied with other results of the trial before changing the severity rating of the part. One must remember that frequently a shipment of a cheaper steel may actually be better than an average shipment of a higher priced grade because of quality variations.

Typical ratings of stampings which are based primarily on maximum strain measurements and the possible grade that might be used successfully on each class of stamping are given in the 1955 ASM Metals Handbook Supplement (p. 2). Although complete dependence cannot be placed on the strain measurement, it is the best single criterion yet to be established.

In some instances, even though the need for premium material may not be indicated by strain measurements, it may be required if buckling is encountered. This problem is sometimes solved by using a steel with a lower yield point – a property found more consistently in higher-priced grades. Generally, proper engineering of the tools eliminates the need for such material. Once the tools are completed, however, it is frequently more economical to try to match the steel to the dies.

How to Evaluate Formability

For years sheet steel producers and users have searched for more accurate tests for evaluating formability. This effort is continuing. However, much valuable information can be obtained from tensile tests. Rockwell hardness and Olsen cup ductility tests are also useful in evaluating formability.

In any test, proper sampling is extremely important. Samples for all tests should be selected, if possible, from the area of the sheet where maximum elongation occurs in the stamping. Rimmed steel, in particular, varies greatly in properties in different areas of a sheet as well as from sheet to sheet.

To obtain the maximum information from tensile tests, load-deformation diagrams drawn with the extensometer gearing at low magnification (about 10 ×) are highly desirable. The principal mechanical properties are yield point, ultimate tensile strength, uniform elongation, and over-all elongation (usually in 2-in. gage).

Fig. 8 – Grid Impression on Stamping Helps Determine Strain Needed to Form Part. Strain or elongation measurements may indicate that cheaper grade of steel would be satisfactory

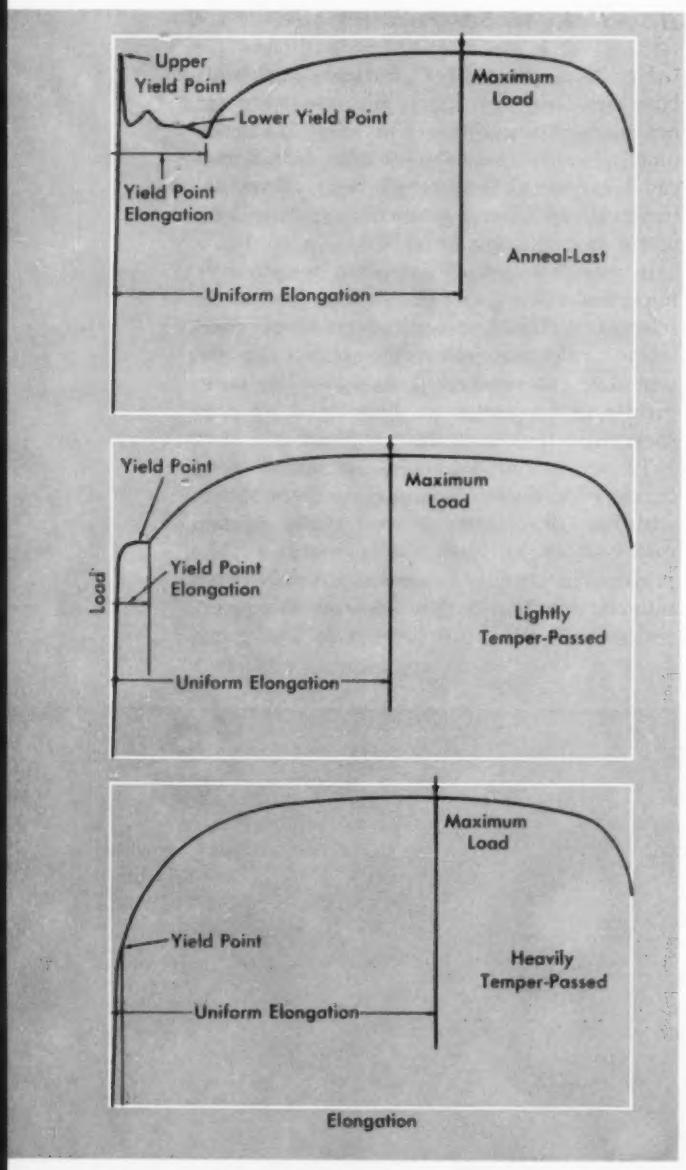
The low-magnification diagram also permits determination of yield point elongation which is helpful in evaluating susceptibility to stretcher strain. The yield point elongation occurs between the upper yield point and the point where the load again resumes a steady increase. A measure of preferred orientation determined by "R" values (ratios of true strain in both directions) can be obtained from the tensile test.

The two elongations are generally the most important properties. When stampings fail, they usually fracture in areas of high strain. The uniform elongation, although frequently not determined, is often more significant than the over-all elongation. Exceptions to this, of course, would be stampings which are quite small or where elongations are very local.

Uniform elongation is more important in stampings which have high elongations in areas that exceed 2 in. in length. For stampings in severity class 1 and 2 (see 1955 Handbook Supplement, p. 2), uniform elongation is not generally used. For severity class 3, 4, 5 R, 5 K and 6 K, desirable uniform elongations are, respectively, 15%, 20%, 24%, 24% and 26% (min.)

Uniform elongation can be obtained from a load-deformation diagram by estimating the strain or elongation where the load first reached maximum. Also, it can be obtained from a ratio of the maximum load to a load at some lower strain (5 to 10%)*. It may also be determined by measurements of so-called "N" values†. The over-all elongation is determined by conventional methods of scribing a standard gage length and measuring the extension after the specimen is broken. Another value, necking elongation, is sometimes useful when stamping strains are highly localized. It is equal to the over-all elongation minus uniform elongation.

Low-carbon steel in the annealed condition has the characteristic yield point shown in Fig. 9 (top). The lower yield point is usually reported. Temper passing or light cold reduction of annealed steel decreases the upper yield point and reduces the yield point elongation. This change is illustrated in Fig. 9 (center). Sufficient temper pass will remove the yield point elongation completely as in Fig. 9 (bottom). On this curve, yield point is arbitrarily



*"Method of Determining the Percentage Elongation to Maximum Load in the Tension Test", by P. G. Nelson and J. Winlock, *A.S.T.M. Bulletin*, January 1949, p. 53.

†"New Criteria for Predicting the Press Performance of Deep Drawing Sheets", by W. T. Langford, S. C. Snyder and J. A. Bauscher, *Transactions*, A.S.M., Vol. 42, 1950, p. 1197.

"Precise Determination of Stress-Strain Curves in the Plastic Range", by J. R. Low, Jr., and Frank Garofalo, *Proceedings*, Society for Experimental Stress Analysis, Vol. 4, 1947, p. 16.

Fig. 9 – Typical Load-Deformation Diagrams for Low-Carbon Steels Showing the Effect of Cold Work. Light cold work (center) decreases upper yield point and yield point elongation. Heavy cold work eliminates yield point. Low-yield strength, high tensile strength and ductility are desired

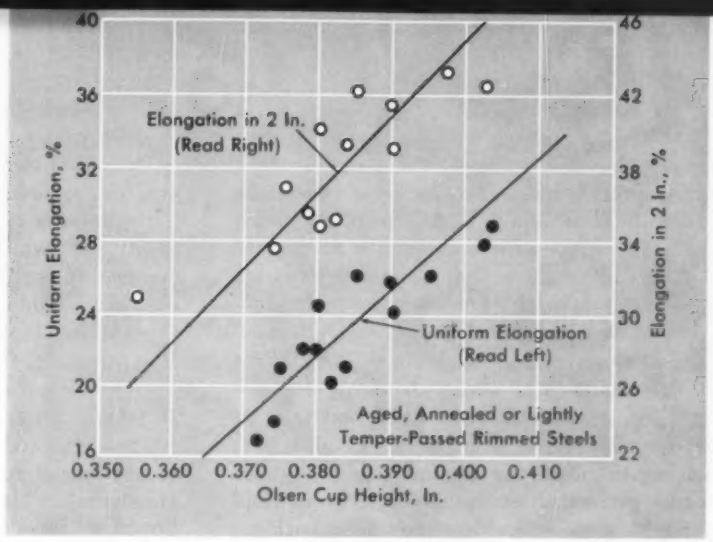


Fig. 10 — Result of Olsen Cup Test (Shown as Cup Height) Compared With Uniform and Over-All Elongation Determined in Tensile Tests on 0.040-In. Sheet. Tests were made on aged, annealed or lightly tempered steels

determined at 0.5% extension under load. With aging, the yield point elongation will reappear on the stress-strain curves of such steels if they are of rimmed grades. Aging will not normally bring out yield point elongation in killed steels which did not originally exhibit it. Usually the amount of yield point elongation in Fig. 9 (center), which is typical of a mildly aged or lightly temper-passed steel, can be removed by roller leveling.

Why Yield Point Is Important

Yield point is of significance in many stampings. To obtain plastic flow in various parts of the stamping, the yield point must be exceeded. This type of flow is occurring over the punch. At the same time, tensile forces exist in the blankholder area. Tensile failure, due to excessive strain, can occur there if too high a force is required to cause flow in the punch area.

If the yield point is high compared to the tensile strength, there is also danger that failure will occur in highly strained areas of the stamping such as corners before metal can be drawn into the die. The ratio of yield point to tensile strength is most significant, but yield point is often considered alone because tensile strength cannot be increased to any significant extent without also affecting it.

High tensile strength is desirable for stampings. In drawn parts tensile forces exist on the metal near the blankholder. These forces result from the pressure of the blankholder on the sheet, the coefficient of friction between blankholder and sheet, and the forming action of the punch. Extremely soft sheet with low tensile strength will fail at lower blankholder pressures than sheet of higher strength. Generally steels of finer grain size have higher tensile strength and are, therefore, more desirable. However, decreasing the grain size

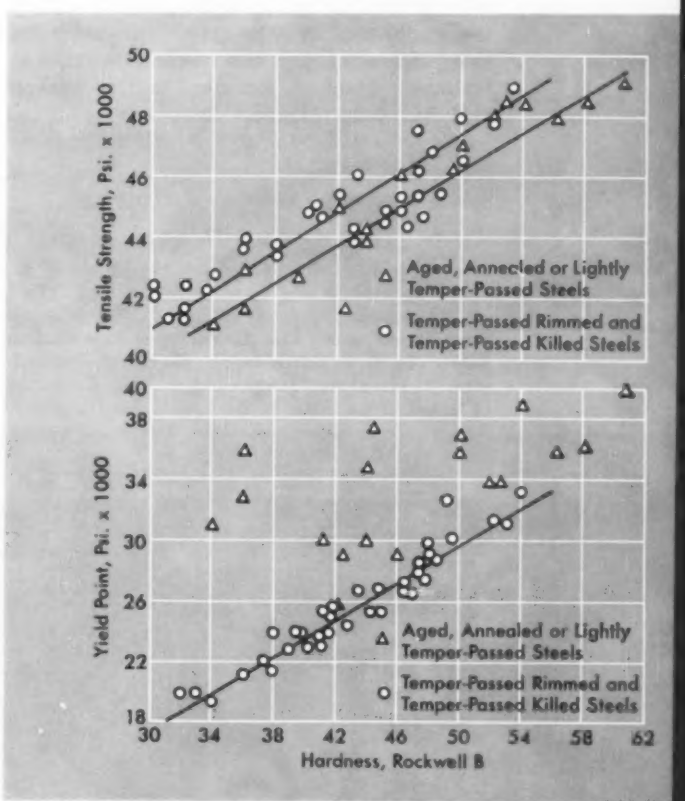


Fig. 11 — Correlation of Strength and Hardness of Aged, Annealed or Lightly Temper-Passed Steels and Temper-Passed Rimmed and Killed Grades. Relation of the two properties is good except in steels which have aged or have been insufficiently temper passed

usually increases the yield point of the steel.

An optimum grain size for most operations is usually about A.S.T.M. 8 (196 to 220 grains per sq.in.). For some operations a finer grain size may be desirable, but for others a coarser structure is helpful. For example, in forming deep drawn parts, the higher strength fine-grained steels will resist the hold-down forces of the blankholder simply because they are stronger. If sheets are thinner and consequently weaker, the higher strength fine-grained steel will again offset the lighter gage. Because coarser-grained sheets usually have lower yield points, they are desirable where elastic buckling tends to occur over the punch face. This is particularly true in flat parts where "loose metal" or "oil canning" occur. Coarse-grained material may give an orange-peel surface after forming which is undesirable for exposed parts.

In recent years considerable interest has been shown in planar directionality as a criterion for drawability of sheet steel. This is discussed by Langford, Snyder and Bauscher (see footnote, p. 92) and R. L. Whiteley (*Transactions*, A.S.M., Vol. 52, 1960, p. 154). Directionality can be determined by measurement of strain ratios known as "R" values. The "R" values can be obtained by measurements of width and elongation of a tensile test specimen with parallel sides. Stanley*, Langford and co-workers and Burns and Heyer† have each outlined methods for determining these values. Whiteley found that the method outlined by Burns and Heyer is accurate and reproducible.

*"Orientation in Low-Carbon Deep Drawing Steel", by J. K. Stanley, *Transactions*, A.I.M.E., Vol. 158, 1944, p. 354.

†"Orientation and Anistropy in Low-Carbon Steel Sheets" and "The Annealing of Low-Carbon Steels", by R. S. Burns and R. H. Heyer, *Proceedings*, International Symposium on the Annealing of Low-Carbon Steel, p. 29, Lee Wilson Engineering Co., Inc., Cleveland, 1958.

The Olsen cup ductility and Rockwell hardness tests are frequently used to evaluate formability because of the speed and relative simplicity with which they can be made. In the cup test, the cup height is dependent upon the over-all ductility of the steel. Unfortunately, the uniform elongation cannot be segregated from necking elongation. Nevertheless, the test gives a fair indication of ductility. Figure 10 relates elongations to cup values for several types of rimmed steel. It will be noted that elongations of typical rimmed steels are fairly closely related to cup values. Killed steels, however, do not show as good a correlation.

As shown in Fig. 11, top, the tensile strengths of annealed, aged or lightly temper-passed steel (the lowest curve) and fully temper-passed low-carbon steels, killed and rimmed (the highest curve) are closely related to Rockwell hardness. Hardness and yield point of temper-passed killed and freshly temper-passed rimmed steel can also be correlated (Fig. 11, bottom). When the steel exhibits a yield point elongation of 0.5% or more because of aging or an inadequate temper pass, there is no noticeable relation between yield point and hardness.

Automotive and similar stampings are often called deep drawn stampings. Drawing, such as cup drawing, is seldom done on outside body parts. Most drawn areas that are present are usually trimmed off. These stampings are actually stretched parts and the final shape results from variable elongation. Stretching the parts gives a surface which is not marred by die marks or scratches.

Stress Pattern Affects Forming Results

There are five stress patterns which may be applied to various areas of stampings during forming operations. Uniaxial tension (Fig. 12) and biaxial tension are commonly encountered in forming operations. Frequently, the most

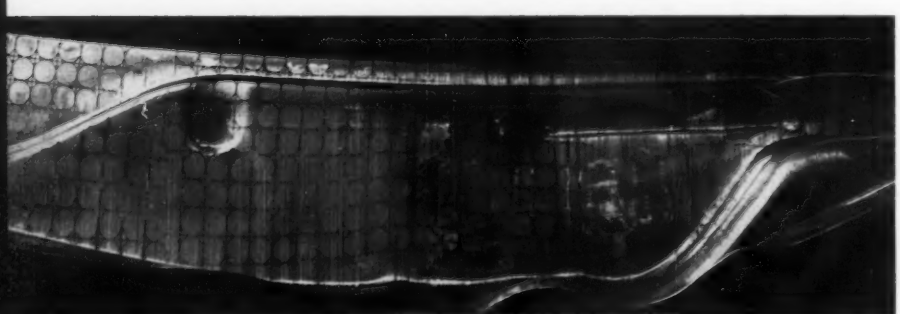


Fig. 12 – Example of Uniaxial Strain Pattern on Formed Part

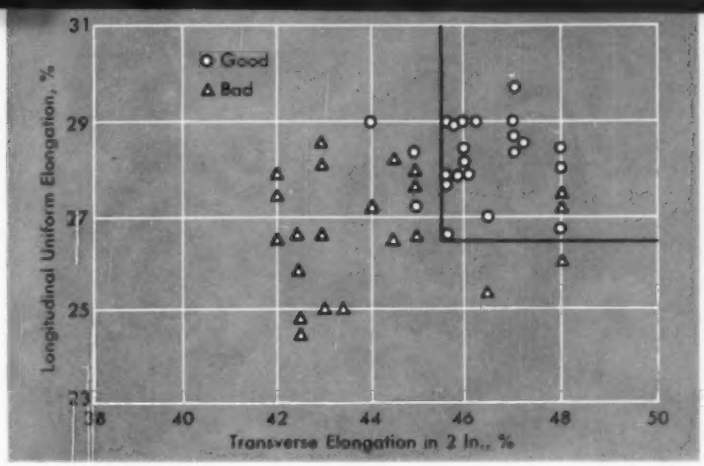


Fig. 13 – Relation Between Properties of Steel Sheet and Performance in Forming an Auto Fender. Each point represents a lift of steel with the indicated properties which have either good (less than 3% scrap) or bad (more than 8% scrap) performance. Chart shows that steel should exhibit at least 45% transverse elongation in 2 in. and 26% longitudinal uniform elongation

severe breakage problems result when elongations from such stress application are excessive. If excessive elongation occurs over a large area of the stamping, the uniform elongation (sometimes called the "N" value) is of most importance. If very local high elongations occur, necking elongation should be considered. Where both types of strain occur, a combination of both elongations or of uniform elongation and elongation in 2 in. may prove most significant. Figure 13 illustrates the correlation that was found between elongations on a very severely formed part. In this part, localized transverse strain was 35 to 40%, whereas, general longitudinal strain was 25 to 30%.

Uniaxial tension plus unfavorable uniaxial compression is annoying because it causes buckling. Shrink flanges (Fig. 14) are a typical example of this. Changes in material properties do not greatly reduce the problems in this type of forming. By drawing the part as a double action stamping and then trimming it, the part can be produced without wrinkles. However, tooling is much more expensive and a larger, more expensive blank is required.

Uniaxial tension plus favorable compression normal to the sheet is commonly encountered in forming channel-shaped parts with tight clearances between punch and die. If compressive forces are excessive, the part will fail on radii because of higher resultant tensile forces. Important properties are low yield point and good elongation. Steels of lower yield point will have less spring back. Those with better ductility will fail less readily at radii.

Uniaxial tension plus biaxial compression is found at the draw radius of deep drawn cups (Fig. 15). Under these conditions, elongations may exceed 70%. In this type of forming, material properties such as yield point, elongations, and tensile strength usually have not proven very important. It is true that purely tensile forces exist at the bottom of such cups where failure commonly occurs. The extent of these tensile forces is dependent upon other factors.

Whiteley found that "R" values are the principal criterion for measuring formability in such a part. More favorable "R" values are found on killed steels than are found on rimmed. However, if draw ratios do not exceed 2:1, a wide range of rimmed steels may be successfully drawn. Often, by adding an additional draw operation, the ratio can be held within this range. This may be more economical than to pay the additional cost for killed steel.

Fig. 14 – Shrink Flanges Are Typical Example of Uniaxial Tension Plus Uniaxial Compression

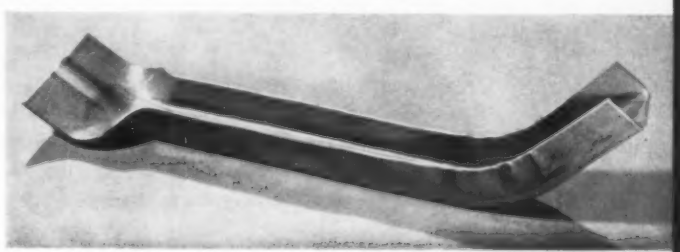
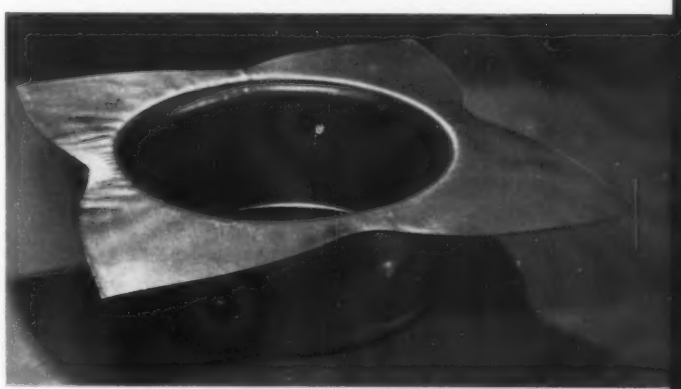


Fig. 15 – Uniaxial Tension and Biaxial Compression Occur During Forming of Deep Drawn Cups



A Report to
Technical Management

Progress in Welding Steels . . .

Vapor-Shielded Arc Means Faster Welding

*By R. A. WILSON**

Vaporization of metal oxides and salts carried in a cored wire electrode provides a shield for the arc in a new welding technique. High operating current and a fast-follow arc characteristic aid in getting welding speeds up to 200 in. per min. (K1d)

ALTHOUGH PROGRESS in the welding industry has been rapid in the past 30 years, it can be accelerated further only by determining fundamental requirements of modern manufacturing and supplying new techniques to meet them. First requisite is that any new welding technique which is to advance industrial efficiency and economy must provide higher welding speeds. Many existing automatic and semi-automatic welding processes obtain this through mechanization. But this characteristic alone has not proved to be the complete answer. Hand welding techniques, for example, still account for 75% of the weld metal deposited. It seems logical, therefore, to conclude that further progress requires going beyond automatic wire feeding. Versatility and adaptability are equally essential.

With these points in mind, we made a careful evaluation of job requirements and decided that a new welding process should include: (*a*) continuous welding by feeding wire from a large coil to improve the operating factor; (*b*) a visible arc that simplifies joint tracking and permits the operator to observe welding progress; (*c*) a bare electrode that does not require flux blanketing, gas shielding, or a special exterior coating to provide shielding for the arc; (*d*) an operating current which is well above typical hand welding settings, thereby achieving higher deposition rates and higher welding speeds.

*Vice-President, Lincoln Electric Co., Cleveland.

New Process Developed

A new process developed to meet these requirements is now being introduced by Lincoln Electric Co. Called Innershield, it employs a vapor rather than a gas to shield the arc and molten metal. Fully automatic installations are welding 16-gage through ¼-in. steel at speeds of up to 200 in. a minute – in most instances at least twice that used with previous procedures. These automatic operations employing a fast-follow arc use currents as high as 1100 amp. The arc characteristics, however, can

Fig. 1 – New Welding Process Uses Vaporized Compounds for Shielding the Arc. Technique fits well into automatic production lines. Being welded at Electric Auto-Lite Co., Toledo, Ohio, is an 888-ft. cylinder which is later cut to 6 and 7-in. lengths for auto generators and starter frames

be changed by altering the electrode design in a manner paralleling that of manual electrodes. Continuing development promises electrodes for fast-fill applications and semi-automatic equipment which will cover a range from 14-gage to $\frac{5}{8}$-in. plate.

As Fig. 1 indicates, the equipment for this new process is relatively simple. A typical installation includes a continuous wire feed mechanism, a d-c. power source, and a control station for adjusting amperage and voltage. The power connection to the electrode is made at the nozzle assembly. No water cooling is required.

The basically new concept of the process is the vapor shielding created by a bare electrode containing vapor-producing materials in its core. Vapor is produced by selected metallic salts and oxides that are introduced into the arc. These melt, boil and vaporize at temperatures below that of the electrode metal. Since they are chemically inert, they shield the arc from the air.

Each metallic salt vaporizes and expands in the heat of the arc, then collapses and condenses as it reaches the isothermal cone corresponding to its condensing temperature. This action forms a series of concentric vapor shields surrounding the arc as shown in Fig. 2. By introducing a number of salts having different vaporization temperatures, the thickness of the shield is increased. Deoxidizers and other materials are also provided by the electrode to assure satisfactory weld quality.

Shield Is Efficient

Excellent shielding and deoxidizing efficiency is achieved with this technique. When a solid vaporizes, it occupies a space 15 to 20 thousand times its original volume. Molecular expansion and contraction during vaporization and condensation achieves the necessary shielding with unusual efficiency. Less than 10% of the electrode's weight is necessary to provide the shielding for most operations. This contrasts with existing methods in which the amount of mate-

rial consumed to perform the shielding action for hand welding is about 33% and for submerged arc welding varies from 100 to 150%.

Because of this high efficiency, all the shielding material can be placed within the electrode, thereby eliminating externally introduced shielding agents, such as gas or flux. This provides greater flexibility in process application. It also assures that the correct amount of uncontaminated shielding material is supplied at all times. Furthermore, vaporization consumes only a small amount of the arc's heat and thus directs more to the job of melting weld metal. All of these factors combine to make a high-speed versatile welding process which in many applications has proven economically superior to previously used manual or automatic welding processes.

Hopper Production Increased

Typical of the applications of the Innershield process is the construction of scrap hoppers, shown in Fig. 3, by Roura Iron Works, Detroit. Previous attempts at mechanizing this application were unsuccessful. Burn-through evolving from poorly fitting joints, plus a good deal of corner welding, were the prime factors contributing to failure. Although the Innershield arc has deep penetrating qualities, it has less tendency to burn through than the submerged arc process or gas-shielded processes working with small-diameter electrodes. The ⅛ and 5/32-in. electrodes used with the Innershield process deposit a wider bead more suitable for the job conditions.

Prior to introduction of the new process, the hoppers were hand welded. Each was completely assembled and tacked before reaching the final welding station. Maximum hand speeds were gained by using a positioner to place all joints in the best possible welding position. Finish welding of the hopper required 1 hr., with hand welding speeds averaging 18 in. a min.

Hand production was doubled to 16 hoppers per day by installing an Innershield head on a boom welding manipulator. The addition of a part-time helper and two more positioners further increased production to 27 hoppers per day with a 1½-man labor investment. These hoppers are built in various sizes but initial production runs have been confined to the higher volume ¾ and 1-yard sizes.

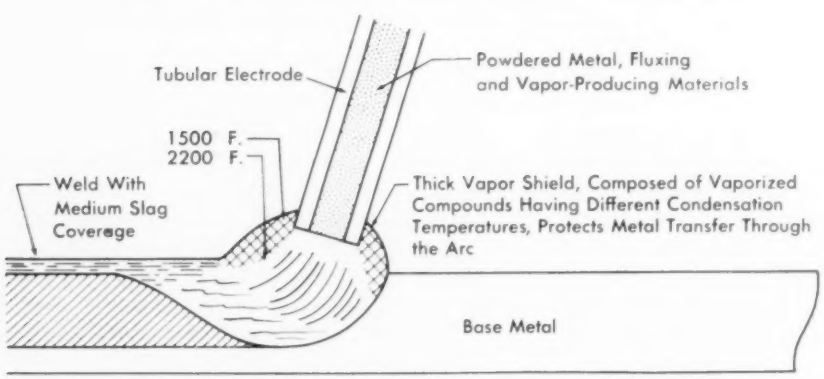
In Fig. 3 the angle stiffeners are being welded around the top edge of the hopper. The welding rate is about 90 in. per min. at 700 amp. and 27 v. A boom fixture solves the problem of depositing welds at right angles to each other without requiring movement of the part.

The 3/16-in. fillet welds on the sides and bottoms of the hopper are also made at 90 in. a min. with a setting of 900 amp. and 27 v. Over 400 in. of weld metal required in fabricating this bucket is deposited at speeds that average five times that of manual welding.

Axle Housings Welded

The new welding process is being successfully used to produce the axle housing illustrated in Fig. 4. Welding speeds average about 150 in. per min. on three different operations. These include welding a reinforcing bead inside the housing butt joint and joining the flanges and dust cap to the housing. Six

Fig. 2 – Arc Shielding in New Welding Process Is Provided by Vaporization of Metal Salts and Oxides Contained in Cored Electrode


Tubular Electrode
Powdered Metal, Fluxing and Vapor-Producing Materials
1500 F.
2200 F.
Weld With Medium Slag Coverage
Thick Vapor Shield, Composed of Vaporized Compounds Having Different Condensation Temperatures, Protects Metal Transfer Through the Arc
Base Metal

machines have been installed in three groups of two each on the axle housing line. Each operator runs two machines, unloading and reloading one while the other is welding.

Converting fixtures to use the new process required little more than interchanging the welding heads and generators. Welding heads and wire reels were mounted in the same position occupied by the previous equipment. New constant potential motor generators with output characteristics designed to suit the new process replaced the older power sources. Because of higher operating speeds, rotating mechanisms in the fixture had to be modified, and hoods were installed to protect the operator from the open arc. Operation of the equipment is basically the same as before because welding controls are very similar.

In fabricating the part, two reinforcing beads are deposited simultaneously inside the housing at the center end of the seams which join the two sections. These 2-in. beads require only 2 sec. to deposit and insure 100% joint efficiency at this point of stress. A workman at the unload side of the fixture cleans the small amount of spatter and loose slag on the weld and places the assembly on a gravity conveyer directing it to the flange welder.

The offset lap welds join the flanges to shoulders formed near each end of the axle housing. This operation is shown in Fig. 4. Switching to the new process cut the arc time for these welds to 8 sec. In addition, the new process simplifies quality control. Should porosity result because of excessive foreign matter in the joint, it is a simple matter to modify the procedure to a two-pass weld. The part makes a second revolution without stopping and thereby insures a pressure-tight joint. It is not necessary to clean the first pass since only a small slag residue remains along the edges of the welds. When the two-pass procedure is adopted, the welding speed is increased and the over-all arc time is about the same.

Cuts Rejection Rate

Hot water tanks made by State Stove & Mfg. Co., Nashville, illustrate another application where this process has been successful. An example is shown in Fig. 5 which illustrates the setup for welding a 44-in. longitudinal seam in a shell of 13-gage steel. This fixture is arranged so that the prerolled, 14-in. diameter shell is raised from a storage conveyer by an air cylinder and slipped onto *(Continued on p. 152)*

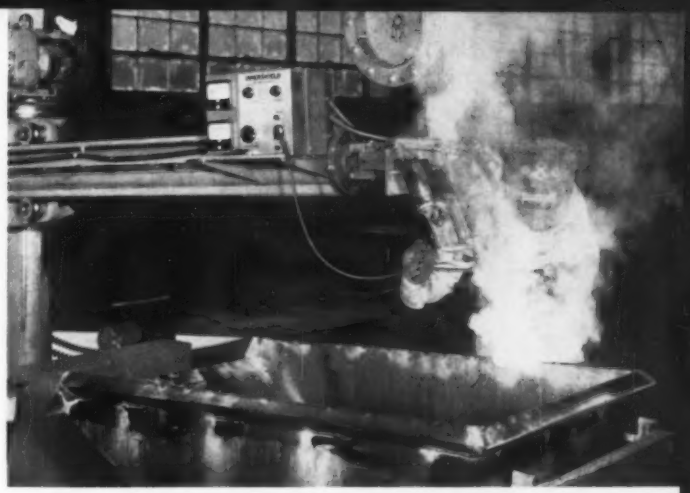


Fig. 3 — Despite Poor Fit-Up Between Parts of Scrap Hopper, Average Welding Speed Is 90 In. per Min. Roura Iron Works in Detroit increased arc time and quadrupled production with only 50% increase in direct labor by using three positioners and mounting the welding head on a boom manipulator

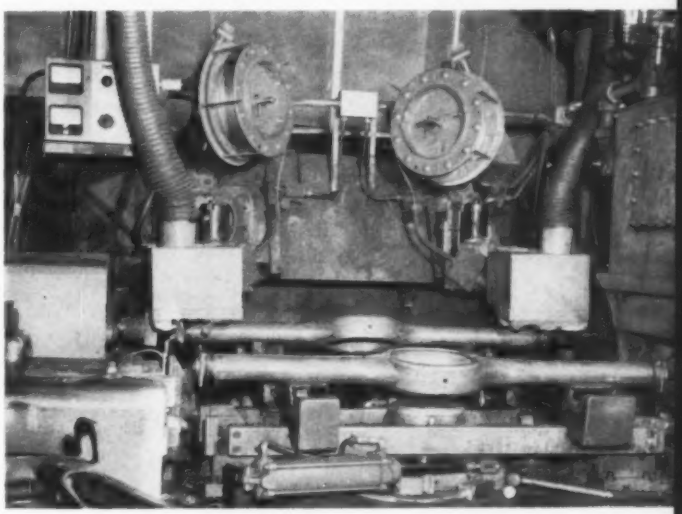
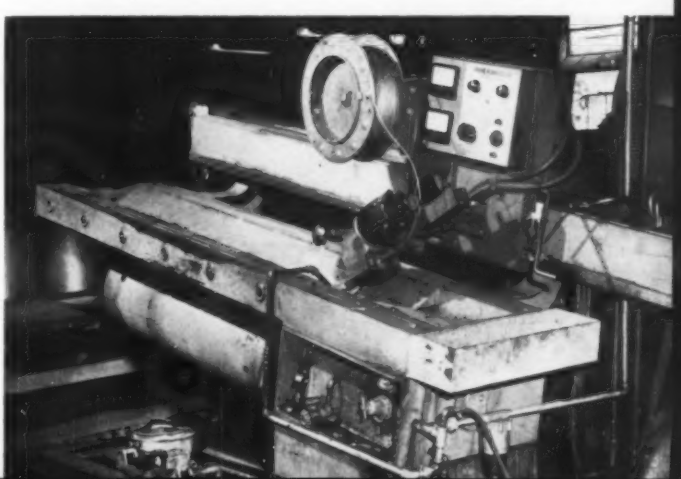
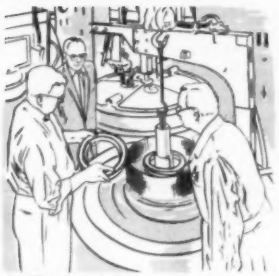


Fig. 4 — Welding the Dust Cap and Flanges of Axle Housings With Vapor-Shielded Process Eliminates Dust, Increases Production Rate and Improves Weld Quality. Flanges are joined to housing in 8 sec.

Fig. 5 — Vapor-Shielded Welding Cuts Rejection Rate in Hot Water Tanks to Less Than 1% at State Stove & Mfg. Co., Nashville. Inclined fixture and welding head permits welds to be made at 155 in. per min.



Technical Management at Work—Harry J. Gilliland, supervisor of metallurgical engineering, manufacturing staff, General Motors Corp., discusses carburizing operation for ordnance ring gear with E. A. Bender (without coat), metallurgical engineer, and C. Chavey, heat treat operator – both also of G.M.'s manufacturing staff. Mr. Bender devised an instrument for measuring quenching rates which is used for production control in heat treating operations.



A Report to
Technical Management

Modern Quenching Techniques Make It Easier to Heat Treat Steel

Today the metals engineer has at his command a wide variety of quenching mediums from which he can obtain almost any cooling rate that he may need. With the proper quenchant, steels ranging from the plain carbon grades to the high-alloyed stainless types can be readily quenched with little danger of cracking or warping. This article details the specific characteristics of each medium, from brine to air, along with descriptions of equipment. (J26, W28p; ST)

THOUGH WEBSTER'S DEFINITION of the word "quench" (to cool suddenly by immersion in a liquid) is basically correct, all metals engineers are fully aware that the quenching operation can be considerably more complicated than the dictionary makes it appear. Heat treaters have available today a wide choice of mediums with which they can quench parts (gears, bolts, piston pins, for example) of virtually any shape at any cooling rate within limits. Often, more than one medium can do the job; then choice depends upon economics. Thus to choose the right quenchant, engineers must have a wide knowledge of all quenchants.

The whole subject of quenching is so complex, it would be useless to quote any general rules. Instead, we will merely discuss the properties and uses of the various quenching mediums in turn, starting with brine (the fastest quenchant) and ending with air (the slowest).

Water, the first quenchant to be used, historically speaking, has one outstanding virtue which causes it to be considered first whenever a quenching operation is necessary. It is by far the least expensive of all common quenching mediums. As a consequence, many researchers have attempted to take advantage of this feature by using additives with water to minimize some of its detrimental characteristics. Additives, such as salt and caustic soda, successfully increase the quenching rate of water, while polyvinyl alcohol additives reduce it.

Quenching in Brine

Water containing an inorganic compound (usually sodium chloride or sodium hydroxide)

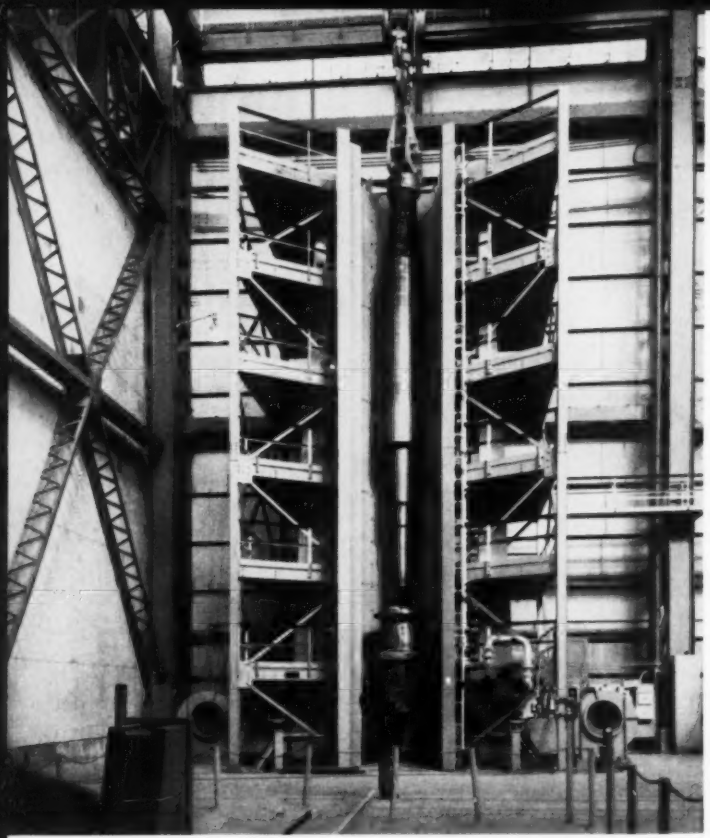
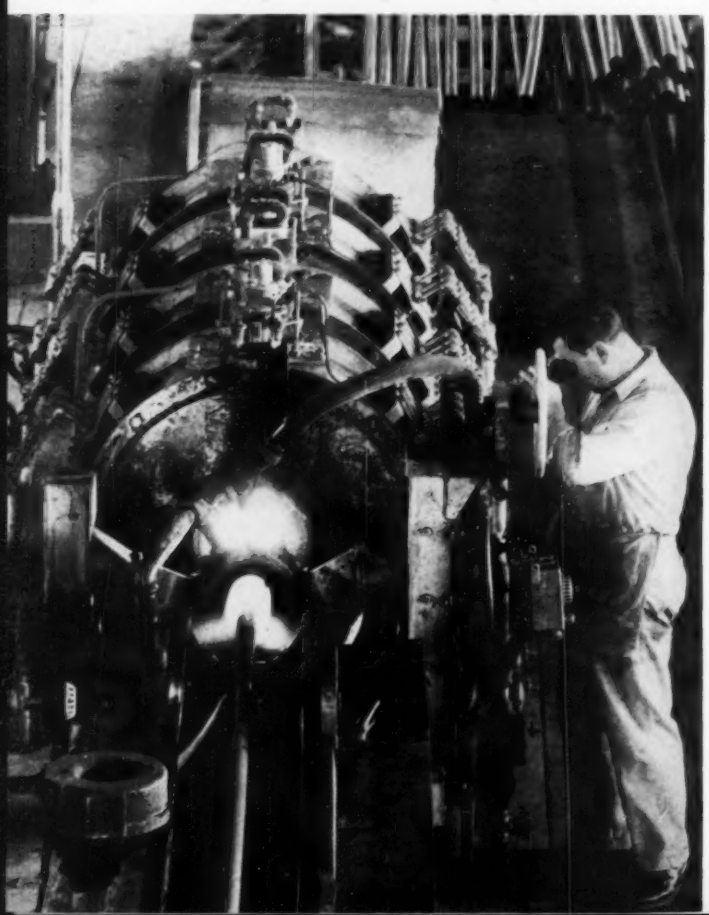


Fig. 1 – Huge Generator Rotor Shaft Being Lowered Into Quenching Tower. When the full-length doors of the tower are closed, the rotor is quenched by jets of air, water, or both. Cooling rates are carefully controlled. (Courtesy United States Steel Corp.)

Fig. 2 – Heated Tubing Is Emerging From Barrel Furnace to Be Quenched by Water Spray From Annular Ring. Such setups can heat treat bar, rod, and tubing at rates of 1000 lb. per hr. "on the fly". (Courtesy Selas Corp. of America)



will quench faster than any other medium.* The mechanism is simple. These compounds are released from the solution as it vaporizes on the hot surface of the part being quenched. As the compounds, now solid, hit the surface they explode. This destroys the vapor blanket, and cooling proceeds rapidly. Inherently, then, this type of quench is no more severe than water. It merely makes a water quench more uniform because the vapor blanket stage is drastically shortened. Concerning concentration, a 9% solution of NaCl or a 3% solution of NaOH is said to be the most effective.

These quenchants are often used where there is some danger of cracking from straight water, but where rapid quenching is still needed. For example, large sections of carbon steel can be hardened with ease. Makers of files for wood and metal also use brine quenchants.

In general, it may be said that a brine quench can be used on a deep drawing low-carbon steel where good mechanical properties are needed. Many shell cases (usually formed from a medium-carbon steel) were made in this manner during World War II. The method is familiar and heat treaters make good use of it.

Quenching in Water

Because of its low cost, water is the most familiar of all quenching mediums, though it has several drawbacks. Because it quenches rapidly to low temperatures, its use is limited to carbon steels in which

*As a matter of historical interest, a "brine" quench was used quite widely by makers of swords in ancient and medieval times. However, their technique is questionable as far as today's ethical standards are concerned. These proto-industrialists, after forging and shaping a fairly sharp edge on the sword, would plunge the red hot blade through the body of a husky slave! Their theory, of course, was that the strength of the slave would pass into the sword. (Actually, the slave's blood, being somewhat salty, as all blood is, merely acted as a brine quench.)

Some Fundamentals of Quenching

Though all three operations – austenitizing, quenching and tempering – in the heat treatment of steel are important, the second step is the most likely to cause trouble because it is the only step in which a rapid change in temperature is essential. (Both heating and tempering can be done slowly if desired.) Warping and cracking of the heat treated part can often be traced to the quenching operation alone. As a result, it has been the subject of much research in the past and today. Because of this work, many quenching mediums are now available for use in many types of processes. This special report is designed to inform metals engineers about the latest developments in the field.

Before getting into the subject, however, some basic principles should be reviewed briefly. While the three stages of quenching are very likely to be a matter of common knowledge, it would be well to recall them. To do this, imagine a piece of steel at about 1600° F., along with a pan of water. When this red hot steel is plunged into the water, a vapor blanket forms over the surface. Due to both radiation and convection through the blanket, heat transfer is fairly rapid, mainly because of the wide difference in temperature between red hot steel and water. However, the blanket also acts to insulate the bar, and thus limits cooling to some extent. As the steel drops in temperature, the blanket thins; finally it ruptures, and the second stage starts. During this boiling stage, heat transfer is at its most rapid rate because heat is being carried away by vaporization of the water as well as by convection and radiation. With water as the quenchant, of course, this stage lasts until the boiling point of 212° F. is reached. When boiling stops, the final stage begins, and continues until the part is as cool as the water. Cooling is now much slower, being achieved chiefly through convection.

Though these three stages are inherent in all quenching mediums, each individual medium has its own personal character. Salt baths, for instance, virtually eliminate the first stage – no vapor blanket forms. With oil quenching, the second stage is shortened because oil has a higher boiling temperature than water. As for brine solution, the vapor blanket stage is virtually eliminated by the nucleating effect of the salt. Conversely, when a polyvinyl alcohol quenchant is used, the first and third stages are lengthened; the water additive inhibits cooling by forming a thin shield around the part. To make a long story short, the engineer can usually choose his quenchant with regard to the quenching rates which the given part needs at different temperatures.

So far, however, the ideal quenching medium has not appeared. This optimum quenchant, when it is invented, will provide rapid quenching from the moment the steel is immersed to the moment it starts transforming to martensite; from that point, the liquid will cool the part slowly and evenly. The first property is needed so that even the leanest alloy steels will not transform to pearlite (or bainite) on cooling; the second is necessary so that the austenite will transform to martensite evenly to minimize cracking. This ideal fluid should flow readily, be noncorrosive, and be economical to use. *Metal Progress* will look forward to the honor of publishing the first article on "Ultraquench" when it is developed. Until then, metals engineers will have to be satisfied with the quenchants which are available today.

there is little danger from cracking or warping. Since water also has a tendency to rust steel, parts which need to be bright must be protected in some manner.

However, water is being used quite successfully by itself in many applications. The huge generator rotor shown in Fig. 1 is a good example. As illustrated, it is entering the quenching tower which is part of the new heat treating setup at the Homestead Works of United States Steel Corp. This quenching tower cools at carefully controlled rates. When the tower doors are closed, the rotor is spun while jets of air or water (or both) spray it until the required temperature is reached.

Good use of water quenching is made in several straight-line production units. Such setups are arranged so that the product – it can be bar, rod or tubing – feeds from gas-fired barrel furnaces through an annular ring from which water is sprayed for quenching. Since, as Fig. 2 shows, the product is quenched "on the fly", no quenching tank is needed; this saves floor space. Water is used in this applica-

tion because it gives the fast cooling rate that is needed to maintain production schedules.

A point to mention in connection with water concerns its growing scarcity in many parts of the country. Though it is still the least expensive of the quenching mediums, it is rising in cost. As a consequence, in some heat treating systems attention is being given to lowering the consumption of water. An obvious method is recirculation. If this is done, however, there must be some means for removing the heat which the water takes up as it quenches. Here is where a heat exchanger comes in. Basically, this item is simply a water cooler in which the coolant is either air plus a water spray, or simply cold water. The quench water circulates in a closed system and is maintained at the correct temperature at all times. According to reports, heat exchangers are being used more and more in efforts to lower consumption of water in quenching.

The "Plastic" Quench

In March 1958, *Metal Progress* was privileged to publish the first report on the polyvinyl alcohol, or "plastic" quench. Developed by P. E. Cary and associates at the research laboratory of International Harvester Co. in Chicago, this method has since taken its place as a recognized production technique. Providing, as it does, a quenching rate somewhere between that of water and oil, it is now being used in many applications. With it, lean alloys which cannot be hardened in oil, but which will crack when quenched in water, can be quenched with little trouble.

This quench achieves its results through lengthening both the first and final stages of water quenching. When the hot steel is plunged into the quench, the vapor blanket persists for a period of time. Then it collapses suddenly, and quenching continues as with water, except for being somewhat slower at the end. Apparently, a film of plastic forms over the part during the latter stages of cooling; this film retards cooling of the metal to an appreciable degree.

Some details on mixing the solution might be of interest. Reports are that each step should be followed with care. The 0.15% mixture is made by sifting the polyvinyl alcohol (in dry powder form) slowly into agitated cold water. Then, the water is heated to 200° F. with constant stirring until the solution is smooth and syrupy. As a last step, antifoam, antimold and antirust agents are added if desired. Concentrated mixtures which contain these agents are also available; they are diluted for use in quench tanks.

Being a fairly new method, "plastic" quenching still has several bugs which have, so far, prevented wider acceptance by the industry. Users have found that the solution is quite sensitive with regard to concentration, agitation and temperature. Thus, each variable should be rigidly controlled for consistent results. Another drawback, according to some workers, is that the solution has been known to dry on guides or fixtures. However, the coating, being water soluble, is easily removed.

Applied in Induction Hardening

Plastic quenching has been widely used in induction hardening. Where selective hardening is necessary, the quenchant is sprayed onto the hot surfaces. In such applications, water cannot be used because there is a likelihood of cracking, and oil is out of the question because of the safety hazard. According to reports, camshafts, gears, and other types of automotive parts (made of 1041, 1045 and 1046, incidentally) are being successfully quenched in production by this method.

Since conceiving the method, engineers at International Harvester Co. have been employing it for many of their quenching applications. Reports of continuing success have inspired expression of interest from other workers both here and overseas. English, German and Japanese engineers are said to be testing the process with the intention of using it in their own production. Meanwhile, plants in this country – Cummins Diesel Co. and White Motor Co. are two examples – employ the method as a regular practice. All in all, plastic quenching appears to be showing real promise despite its reported drawbacks. With continued research, as time goes on, many of these problems will undoubtedly be solved.

Oil Quenches

The next group of quenching mediums, on the basis of quenching rates, are the various types of oils. Here, as with water, a range of quenching speeds is also available. There are the "fast" oils (which contain surface-active additives), the "straight" (or, technically speaking, the 100-sec. viscosity) oils, and the "hot" oils (which are heated to as high as 450° F. to approach the salt bath temperatures used in

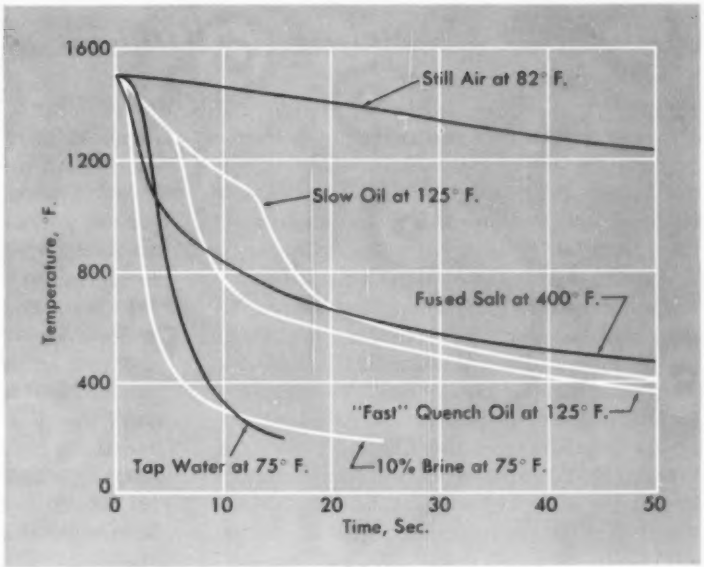


Fig. 3 – How Several Quenching Mediums Compare as to Cooling Rates. These curves were determined by measuring the temperature changes in the centers of 18-8 stainless steel specimens, ½ in. diameter by 2½ in. long. Solutions were not agitated. (Courtesy Gulf Oil Corp.)

martempering). As the following will show, each type has its advantages and disadvantages.

Quenching in "Fast" Oil

Remembering that steels with smaller amounts of alloy are being used more and more, and also that there is a "gap" between water and oil as far as quenching rates are concerned, the reason for attempts to evolve faster quenching oils will be apparent. This work has been carried on by several companies, and a number of such oils are available.

These oils contain additives which are designed to shorten the duration of the vapor blanket stage. The purpose is to approach the quenching rates of water at higher temperatures while retaining the quenching rates of oil when the transformation range is neared. (In that respect, incidentally, oil is better than water because it boils at a higher temperature – one which more closely approximates that of the M_s point.) These additives can be purchased separately to add to conventional oils.

Since their introduction, fast quenching oils have been adopted by many users. A few examples will illustrate this. Success has been reported in quenching such items as spring clips and fasteners (A.I.S.I. 1064, 0.010 to 0.064 in. thick), cartridge clips (WD 1045), and spindles for door closers (S.A.E. C-1137). Recently, fast oils have also been applied in quenching carbo-nitrided rasp blades. In short, these oils find their greatest application in situations where water will crack or distort the part, and where ordinary oils will give uneven hardening. They are also quite useful when quenching lean alloy steels.

Another application in which fast quenching oils are useful is in bright hardening. When parts must retain a bright finish, they are heat treated under a protective atmosphere. In quenching, however, a conventional quenching oil does not "wet" the smooth, shiny surface of such items. (The oxide-free surface apparently acts to retain the upper blanket.) The action of fast quenching oils enables the quenchant to cling to the part, and thus more even cooling results.

Manufacturers warn against the use of water-oil emulsions as a means for attaining quenching rates between those of water and oil. Such solutions have no effect other than to prolong the first two stages of quenching – and from a metallurgical standpoint, these two stages should be shortened rather than prolonged.

Figure 3 illustrates cooling curves which result when various quenchants are used without agitation.

In comparing fast, medium and slow oils, violent agitation will act to minimize the differences in quenching rates. But agitation is not always so successful. Though it may be the answer for parts of simple geometry (cylinders or spheres, for instance), complex parts are likely to be subject to differences in agitation at different sections (because of nonuniform cir-

*Automatic Quenching of Ring Gears**

As a standard practice, ring gears for automobiles are die quenched. Why is this necessary? Because such gears distort in carburizing and in quenching. Consequently, they must be "trued up" by dies to maintain dimensions within the required strict limits.

Though essential, die quenching used to be somewhat cumbersome. Earlier quenching presses were loaded and unloaded by hand, and parts were handled one by one. This meant a large investment in presses. To illustrate, an earlier installation in the Chevrolet plant at Buffalo, N. Y., required 12 separate presses to handle the output of each continuous furnace (used for gas carburizing gears of A.I.S.I. 4028). In their new installation, an automatic press (a Gleason 117 quenching machine which has since been superseded by the newer 509 quenching machine) replaces the 12 units. Less floor space is needed, handling problems are reduced and quality is better.

Automatic Handling – This Buffalo plant, incidentally, is leading the field in applying automatic handling techniques to heat treatment. The model installation features continuous furnaces throughout, as well as the automatic die quenching machine already cited. Together with plenty of care in the earlier turning, grinding, and cutting operations, these unusual heat treat facilities turn out thousands of gears of outstanding quality and uniformity.

Their setup is simple in operation. After the teeth are cut, all gears and pinions are gas carburized in Holcroft continuous pusher-type furnaces, equipped with fans which circulate the atmosphere to provide uniform case depths in production lots. (As a sidelight, when a recent failure caused the furnaces to be run for a few days without the fans, their value in providing dimensional uniformity was borne out dramatically. Also, without the fans it took 25% longer to achieve the required case depth.)

The furnace exit arrangement shows the same emphasis on automatic handling of both pinions and ring gears. To be more explicit, after pinions leave through the side exit of the furnace, they are automatically lowered into the quenching coil. Then, they travel around the rotary quench tank until they are unloaded. As for the drive gears, they exit at the main door, from which they are transferred to the No. 117 quenching press. Parts are loaded in front of the unit; the rest of this unique quenching process is entirely automatic.

New Quenching Machine

The new No. 509 quenching machine merits some description. Basically it is a press for die quenching gears and other flat parts up to 10½ in. diameter and 4 in. high (or up to 8 in. high with some additional bracketing arrangements). If desired, automatic handling equipment may be attached for high production.

A new arrangement for "pulsing" die pressures improves the quality of the quenched parts, and, in most instances, increases production rates as well. This "pulsing" technique, incidentally, is the heart of the quenching machine setup. Unlike most press quenching methods, the pressure is not maintained throughout the cooling cycle. Instead, pressure is "pulsed" on and off for only the first few seconds of cooling from the austenitizing temperature. Since the gear is free to contract

*Prepared from information supplied by Gleason Works, Rochester, N.Y.

culation). With slower oils, this can result in a nonuniform quench. Further, under such conditions, uneven hardnesses will result if the chemical analyses are critical with respect to transformation rates.

Conventional Quenching Oils

Despite the success of fast quenching oils in many applications, most oil quenching is still performed in conventional, 100-sec. viscosity oils. With these, the quenching action is characterized by a vapor blanket stage, which is fairly short, along with a boiling stage that ceases to function at a temperature which is in the vicinity of the M_s point for many steels. The third stage, which begins when boiling stops, lasts longer than does that of water.

Since slow cooling is desired in the marten-

normally (instead of being under constant restraint from a die), stresses do not develop from friction due to die contact.

In devising this system, engineers at Gleason also reasoned that there was little value in restraining the gears at lower temperatures. As is well known, when the temperature drops, the yield point rises. Eventually, the gear becomes so stiff that no further change in dimensions is possible.

The entire machine operation is controlled with simple timers and push buttons. Dies may be changed quickly, and sections of the universal lower die may be adjusted independently.

Features and Operation

Oil is carefully controlled to flow evenly over the entire part. The flow may be varied by present controls to obtain, for example, *(a)* a fast, drastic quench until the critical point of the hardening temperature is passed, followed by *(b)* a slow quench to allow the temperature at the outside surface and at the center sections to equalize, and *(c)* a rapid cooling quench to bring the part to handling temperature.

In automatic handling, "pulsing" takes place during the first portion of this quenching sequence during which the gear is held in the die. Since these dies are surrounded with a pan arrangement, the part is still submerged in oil after it is released from the dies. Each part remains in the die chamber only until further holding will no longer change the final dimensions (about 6 sec.); the remainder of the cooling operation is a "free-quench".

In the automatic machine, the parts are transported under oil and lowered in an elevator to be placed side by side on the submerged conveyer belt. This belt indexes as new parts are quenched, until the cooled parts emerge above the oil level and are ejected at the rear of the machine.

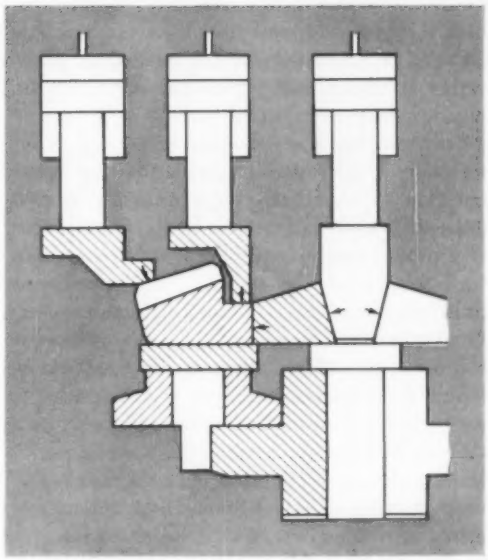


Fig. 1 – Pulsing Action in Automatic Die Quenching Press for Automotive Ring Gears. As the gear leaves the furnace, it enters the press to be positioned by the upper die. While the oil flows evenly over the part, the pressure is "pulsed" on and off at the indicated points. This pressure is only applied for a short time (about 6 sec.); after that, the part is released to cool in a free quench

Trends in Quenching

The development of suitable transfer mechanisms is the prime target of quenching automation today. In other words, we want to get the part from the furnace to the press in the quickest way and in the greatest numbers.

Development toward new types of transfer fixtures is being thought out at the Gleason Works and other furnace companies. In addition, highly automatic presses will find application in the bearing field, and in any other high-production items where distortion from quenching is a problem.

sitic range, oil quenching is very useful when heat treating most alloy steels. However, such steels must have enough alloy so that they will not transform until the M_s is reached. Thus, oil quenching finds its greatest use in quenching the higher-alloy steels.

With these slower quenching oils, agitation becomes a very important factor. The day of the manual "figure-eight" quench being virtually over, mechanical agitation methods now receive the most attention. Basically, there are two systems; either impellers (pumps) or propellers can be used to stir the oil. For dense, highly compact loads (for example, small gears which fit closely together), impellers are almost a must because they will move volumes of oil. Forcing the quenchant around and through the small crannies as they do, they quench more

evenly. Propellers, on the other hand, will merely stir the oil, and for dense loads this is not enough. Currents of oil, instead of penetrating the load, will go around it. Only the outside will then be quenched.

Yet propellers have their place. For a given horsepower, propellers give about ten times the agitation as impellers. Or, conversely, a propeller will need but one-tenth the horsepower to provide stirring equivalent to an impeller. Furthermore, as Fig. 4 shows, it is possible to build systems in which propellers will circulate the liquid with somewhat the same efficiency as impellers. (That illustration, incidentally, depicts a salt bath installation, but the principle can be applied to oil quenching setups.)

Many builders of oil quenching systems prefer the impeller type of pump because it provides more positive cooling. Since large volumes of oil are moved rapidly, the high static pressures of the pump can be converted into high oil velocities at jets positioned around the load zone. The oil then penetrates the load with ease to cool rapidly and carry the vapor away from the hot surface.

Cooling the Oil – Another factor to consider in oil quenching systems is the matter of removing heat from the oil after it quenches the load. For consistent results, oil should be maintained at approximately the same temperature (usually about 125° F. to keep viscosity low) at all times during the operation. Heat exchangers for this purpose can have two arrangements; the cooling coil, which contains water, may run through the oil (shell-and-tube type), or the oil may run through a coil which is sprayed with water (spray-tower type). One manufacturer feels that it is best to have the first setup with the water coil being surrounded by oil under a high pressure, since there is less danger of water leaking into the oil (because of the pressure difference between the two mediums). Also, the high velocity of the oil on the surface of the water coil is conducive to efficient transfer of heat.

As mentioned before, the spray-tower type of cooling unit is usually employed if water must be conserved. It makes use of the "latent heat of vaporization" principle. In this, water is sprayed onto pipes in which the oil circulates. Since this water vaporizes as it hits the hot pipes, heat is taken up to be dissipated in air. This type of cooler is more expensive than the shell-and-tube type, but much less water is needed. In fact, heat extraction is such that the latter type of cooler will use about 50 times less water than the shell-and-tube type for an equivalent degree of cooling.

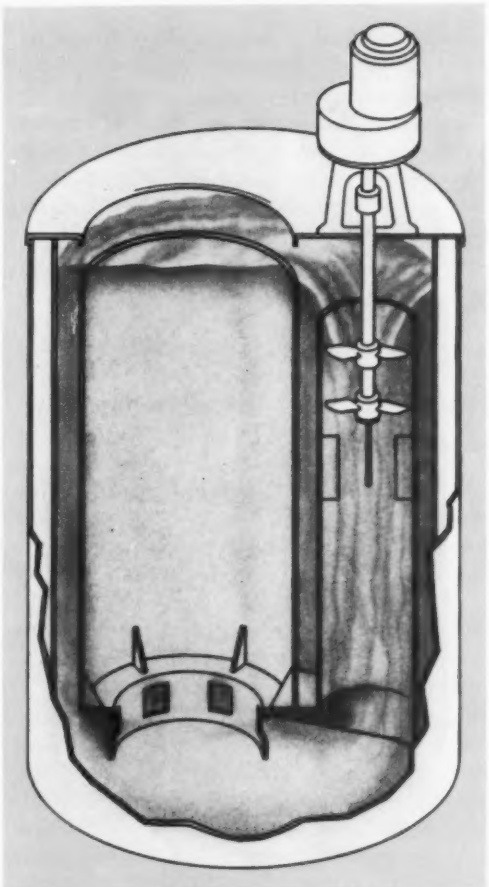


Fig. 4 – Diagram of Quench Tank Which Employs Propeller-Type Agitation. Propellers can be used to agitate all types of quenching mediums. (Courtesy Lindberg Engineering Co.)

Installations which employ oil are many and varied. One novel arrangement, used in a West Coast gantry furnace which heat treats missile motor cases, is equipped with an unusual type of quench tank. The rocket case was closed at one end, yet it had to be quenched from both the inside and outside. The problem was solved by installing a vertical breather tube, 10 in. in diameter, through which air would be expelled as the case was dropped over it, and its mouth was submerged deeper and deeper in the oil. When the case was completely submerged, the air was pumped back through the same breather tube to agitate the bath. Thus, the quenching

setup used the same tube for both air and oil.

In recent years, there has been a growing interest in hot oil quenching – in oil maintained from about 200° F. to as much as 450° F. The idea behind this is to provide a martempering process. In other words, the steel parts are quenched in oil to the neighborhood of the M_s temperature, allowed to reach even heat throughout, and finally removed to cool in air. Transformation of austenite to martensite (and its accompanying large change in volume) therefore occurs more or less simultaneously throughout the part and distortion is minimized.

Problems in Hot Oil Quenching

Of course, the use of hot oil brings its own problems. An obvious drawback is the instability of oils at higher temperatures. Heat will "crack" oils and produce sludge which, in turn, will clog the circulating pipes. Also, oils with extra high flash points are needed; these oils will naturally be more sluggish at lower temperatures. Since heat will decompose oil in air, a protective atmosphere is often needed over the bath. Because of this, the bath is usually enclosed. Such added refinements naturally raise the cost of construction.

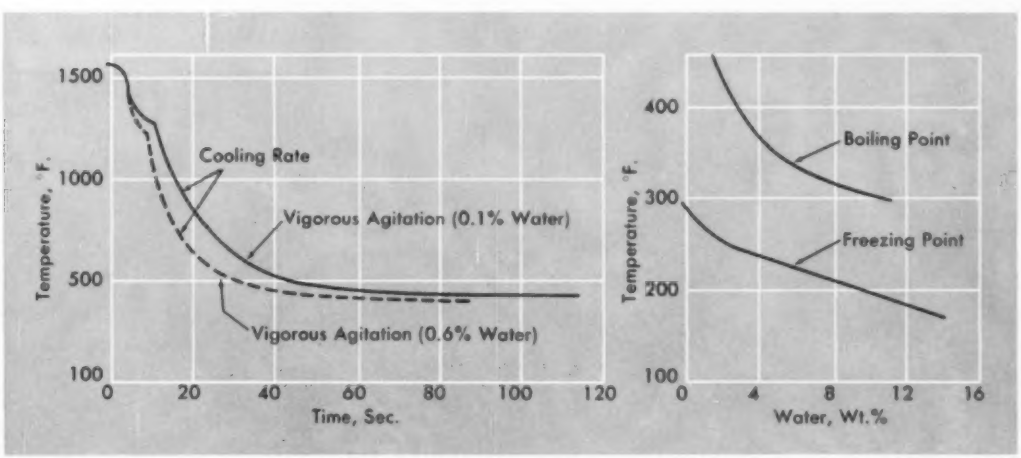
Hot oils are used in a variety of applications where martempering is called for. As an example, a tractor manufacturer in the Midwest uses hot oil for quenching carburized gears. In carburized parts the case, being higher in carbon, will transform at a lower temperature than the core. Further, the core transforms to bainite while the case changes to martensite. (In this instance, hot oil was chosen for economic reasons; salt baths would have given the same results, metallurgically.)

As might be expected, the major problem was short life of the oil. To correct this, several steps were taken. First, fuller's earth was employed for filtering; this raised life expectancy to 600 hr. When agitation was found to increase viscosity (agitation aerates the oil, and it oxidizes to become more viscous), the setup was altered so that the oil would be heated and stirred during the quench cycle only – and oil life rose to 1600 hr. Finally, a protective atmosphere was added. When this improvement increased oil life up to 12,000 hr., the engineers figured they had gone far enough.

In this particular application, safety was of some concern. (From the standpoint of potential fires, oil causes more trouble than any other quenching medium.) After considering the requirements, a procedure was established which required a daily check of the control temperature. There is also a separate overheat control set at 450° F., a method for determining the degree of agitation, an oil level control, and a water sprinkler system.

Improved Oils for the Future – Interest in hot oil continues in many quarters. As an example, a manufacturer of heat treating equipment and an oil company are cooperating to develop an installation for oil that will give satisfactory results when quenching at any tem-

Fig. 5 – Effect of Water Additions to Salt Baths. Water increases the cooling rate of the nitrate-nitrite salt, and also lowers the boiling and freezing points. (Courtesy Ajax Electric Co.)



perature between 200 and 450° F. Work is nearing completion on this project.

In this work, problems have arisen because of the inherent characteristics of oil. As is well known, all oils become less viscous as temperature rises. Since the oil will need a high flash point (in the vicinity of 550° F. usually) to be used at 450° F., it will generally be quite viscous at 200° F., and high viscosity impedes the quenching action to a degree.

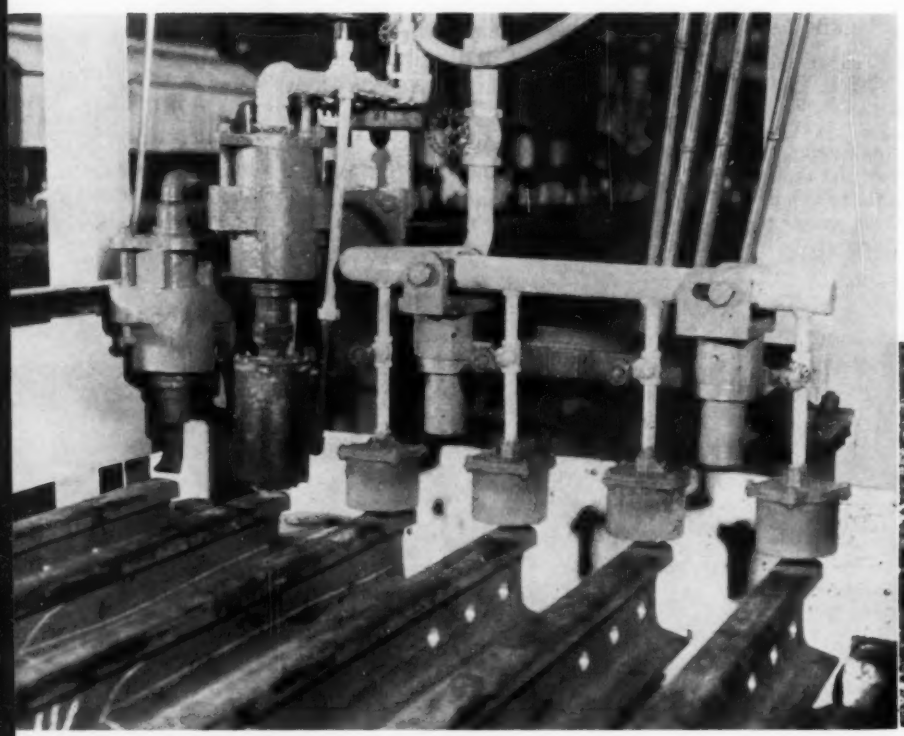
Salt Quenches

Salts, being somewhat more costly than either water or oil, are not used as extensively for quenching as the other two types. However, they have a definite place, particularly when the parts must be austempered or martempered. In fact, some manufacturers prefer salt for martempering (as opposed to hot oil which, as mentioned before, can also be used) because higher working temperatures can be maintained. Salt is also more stable than hot oil. As a general rule, anything that can be quenched in oil can be quenched in salt. (Parts previously hardened in cyanide baths are exceptions, of course.) Further, there is no vapor blanket to consider when salt is used.

Be that as it may, both austempering and martempering long ago became established as effective heat treating methods, and as a consequence there is little that is new concerning either process. However, refinements appear from time to time, some of which are worth discussing. One of these concerns the addition of water to the salt bath to increase the quenching speed.

Water With Salt – Normally, most heat treaters feel that water and salt should not be combined because of a potential safety hazard. Bad explosions have been known to result when water accidentally came in contact with hot, molten salt. Water, however, can be added intentionally by introducing a stream (through a small tube) at the vortex of the salt around the whirling shaft of the mixer. The turbulence then carries the water into the bath without danger. As to its effect, when water is added to the salt bath, the melting point is lowered and the quenching speed rises (see Fig. 5). Naturally, when the bath will quench more rapidly, the steel to be martempered or austempered can get by with a smaller amount of alloy. This may be advantageous, economically.

Today, low-temperature salt baths, which use



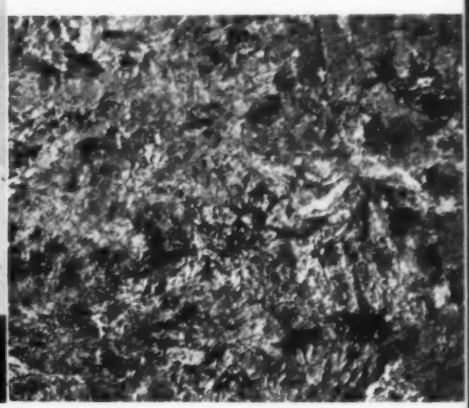


Fig. 6 – Air "Quench" Hardens the Ends of Railroad Rails. Four stations, at right, preheat ends, and the fifth station austenitizes them. Finally, a blast of cold air, compressed to 100 psi., quenches them to hardness of Rockwell C-40. Inset shows fine pearlite structure 1/8 in. from end of rail. (Courtesy Selas Corp. of America)

In the course of collecting and organizing the material for this Staff Report, the editors contacted many technical people in companies engaged in various aspects of the quenching operation. We acknowledge the help of these companies, for without the willing cooperation of their talented engineers, this article could not have been written.

Ajax Electric Co., Philadelphia
Bell & Gossett Co., Morton Grove, Ill.
Dow Furnace Co., Detroit
General Motors Corp., Detroit
Gleason Works, Rochester, N.Y.
Gulf Oil Corp., Pittsburgh
Hevi-Duty Electric Co., Milwaukee, Wis.
Holcroft & Co., Detroit
A. F. Holden Co., Detroit
E. F. Houghton & Co., Philadelphia
International Harvester Co., Chicago
Lindberg Engineering Co., Chicago
Niagara Blower Co., Buffalo, N.Y.
Pacific Scientific Co., Los Angeles
Selas Corp. of America, Dresher, Pa.
Surface Combustion Corp., Toledo, Ohio

nitrates, usually have some system for separating chlorides, because the latter will lower the quench's effectiveness. (They can be introduced from high-temperature salt baths used in austenitizing.) The salt flow is either channeled through a settling chamber maintained at a lower temperature than the treatment bath, or an additive is employed. Suppliers of these low-temperature salts can also provide kits by which the chloride content of the nitrate mixture can be determined.

Salt bath units have been getting larger in recent years. Today, huge gantry furnaces, used for heat treating cases for rockets and missiles, employ equally huge salt baths for quenching these cases.

Air Quenches

Actually, air is usually not considered to be a quenching medium. However, there are certain circumstances when it becomes quite useful. Though it might not be suspected, air has several advantages. Certainly, it is economical, probably more so than water (though it unquestionably does not have the cooling power). Furthermore, no containers are needed, nor is any protection necessary. Air is also unlikely to be contaminated, and it is perfectly safe. On the whole, engineers who are faced with quenching problems might do well to consider the potential of air. To illustrate what it can do, the following example is given.

Figure 6 shows an installation which heats and hardens the end of railroad rails. The first four gas-fired heaters preheat the ends to 1000° F., and the fifth, a contour heater, boosts them to 1600° F. As a final step, the rail ends are under 100 lb. pressure. The structure of fine pearlite which results has a hardness of Rockwell C-40; residual heat left in the rail tempers these ends after the air blast stops. Three major steel plants have similar installations.

Summary

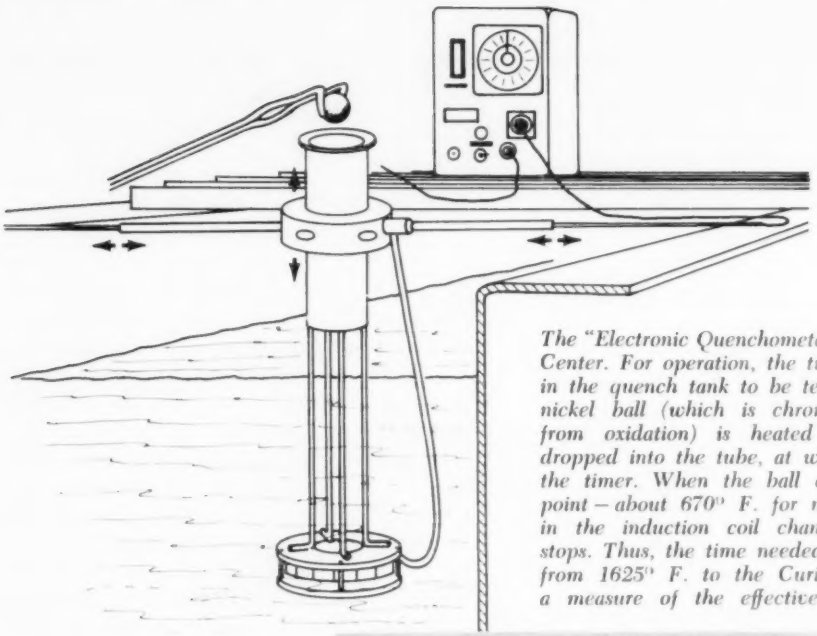
Our hope is that this article, which basically gives the characteristics and uses of the various types of quenchants now available, will spur engineers to further and still more productive work in this field. As we mentioned in "Some Fundamentals of Quenching" (p. 103), the ideal quenchant still awaits invention. Maybe you will find it.

Measuring Quenching Rates With the Electronic Quenchometer

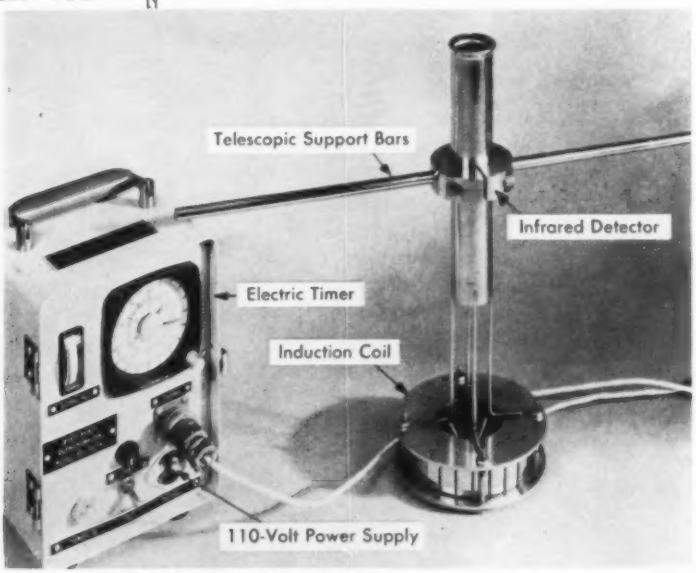
*By H. J. GILLILAND**

BECAUSE OF THE MANY VARIABLES which affect the quenching operation, the heat extraction rate of quenching mediums has, until now, been a mystery to many heat treaters. This is partly because engineers have lacked an accurate method to evaluate the effectiveness of a quenchant in a given system. This gap, we feel, has been filled by the "electronic quenchometer". As illustrated overleaf, this is a

*Supervisor, Metallurgical Engineering, Manufacturing Staff, General Motors Technical Center, Detroit. The instrument described in this article was devised by E. A. Bender, a metallurgical engineer on the manufacturing staff.



The "Electronic Quenchometer" of G.M. Technical Center. For operation, the tube is first positioned in the quench tank to be tested. Then, the pure nickel ball (which is chromized for protection from oxidation) is heated to 1625° F. and dropped into the tube, at which time it actuates the timer. When the ball cools past the Curie point – about 670° F. for nickel – the reactance in the induction coil changes, and the timer stops. Thus, the time needed for the ball to cool from 1625° F. to the Curie point of nickel is a measure of the effectiveness of the quench



device which tests and compares quenching mediums under actual production conditions.

An adaptation of the magnetic quench test (described in the A.S.M. booklet "Quenching of Steels"), this test procedure makes use of the metal property known as the "Curie point", the temperature at which a ferromagnetic metal loses its magnetism on heating. The ball used in this test is composed of commercially pure nickel which has a Curie point of about 670° F., a temperature which is below the noses of the S-curves for most metals.

How It Works – As the diagram illustrates, the electronic quenchometer consists of a tube attached to an induction coil. Appropriate timing and electronic equipment are also included. When an oil is to be tested, the tube is immersed in the quench tank. The nickel ball, which is chromized for protection from oxidation, is heated uniformly to 1625° F., and dropped into the tube. Located in the fixture just above the quenchant level is an infrared detecting device which starts the timer as the ball enters the tube. As the ball cools below about 670° F., the Curie temperature, it regains its magnetism. This changes the reactance in

the induction coil to excite a relay which shuts off the timer. Elapsed time as indicated on the timer is a measure of the heat extraction power of the quenching medium.

With this device, then, the effects of variables such as foreign matter contamination, oxidation and aging of the quenchant, circulation, and temperature in the bath can be determined. Also, the quenchant can be checked periodically to determine how it changes with time and use. As an example, the accompanying graph (Fig. 2) shows the relationship of heated oil and various degrees of circulation to quenching speed. The data indicate that agitation increases the quenching speed of a slow, conventional mineral oil (A) more effectively than it does the quenching speed of a premium grade oil (B). In each instance, however, a major part of the increase in cooling power is realized with a relatively small amount of agitation – about 2 to 4 ft. per sec.

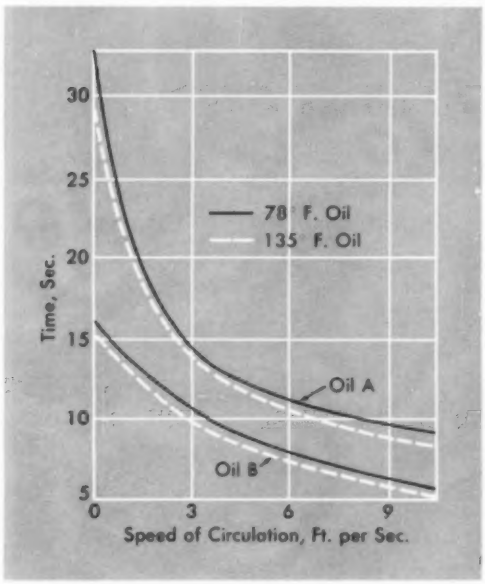


Fig. 2 – Graph Showing Effect of Agitation as Indicated by Quenchometer. Agitation increases the quenching speed of the slow, conventional oil (A) much more than it does the speed of the premium-grade oil (B). Also, the heated oil quenches somewhat faster because its viscosity is lower

As a comment, however, although it is conceivable that the heat extraction rates of the two oils might become equal with extremely violent agitation, racking of parts and irregularities in part shape would certainly prevent heat from being removed uniformly in a production quenching operation. (The data also show that increasing the oil temperature to 135° F. produces faster cooling; this agrees with practical experience.)

The Quenchometer in Practice – The electronic quenchometer has been used in many divisions of General Motors. For example, one plant spasmodically encountered cracking of S.A.E. 1335 steel parts. When the quenching system was checked, we found that oil temperatures were higher than normal. This allowed more rapid circulation, and the cooling rate increased enough to cause cracking in an area of an abrupt section change. The electronic quenchometer detected this increase in quenching rates.

From time to time, another division experienced variations in hardening. Upon investigation, we found that a chemical compound had been used to extinguish oil fires. Apparently, a critical percentage of this powder, when suspended in oil, actually increased the cooling power of the quenchant; further, excessive amounts caused the quenching speed to drop. Interestingly enough, another G.M. division had an identical experience with the same extinguishing powder.

Still another plant had occasional difficulty in obtaining full hardness from 1141 steel gears which had been quenched in a conventional, 100-sec. viscosity mineral oil. After testing, a proprietary additive was blended in the oil. When we then tested the modified oil, we found, in accordance with our past experience, that it had a much greater cooling power than the straight mineral oil. It was now good enough to harden the parts fully and maintain specifications. The division, after more than a year, still maintains this successful quenching system for their 1141 steel gears.

More work with the quenchometer goes on continually. We are now trying to determine the influence of temperature and circulation of molten salt, in the range of 300 to 450° F. This work was initiated because of the current interest in salt quenching as a method to minimize distortion and alleviate cracking of critical parts. Our results, when they are completed and ready to be reported, will be published in a forthcoming issue of *Metal Progress*.

Technical Management at Work — M. F. Garwood, chief engineer, Materials Laboratories (standing, center) leads a discussion on dimensional tolerances of integral transmission case and converter housing made of aluminum by die casting. Other Chrysler Corp. engineers include (from left to right) J. J. Manganello, supervisor of materials development in the cast metals laboratories, W. H. Grundeman, managing engineer of the physical metallurgy laboratories, and H. H. Zurburg, assistant chief engineer, metallurgical development.

"We constantly review our specifications seeking out less costly materials in order to remain competitive. If there is another material which can be properly processed, satisfies the physical requirements, and results in a cost reduction, we try to use it."

M. F. Garwood

A Report to
Technical Management

Materials and Process Applications in the Automotive Industry

*By M. F. GARWOOD**

An account of recent trends and future prospects in these important areas: Aluminum die castings . . . Pearlitic malleable iron castings . . . Cheaper alloy steels . . . Aluminized valves . . . Parts from powder metallurgy . . . Cold extrusion of steel . . . Resistance welding . . . Protection against corrosion . . . Duplex nickel plate for bright trim . . . Better paint finishes . . . plastics for auto parts. (T21, 17-57)

Aluminum Challenges Other Metals

. . . Die Casting Process Is Ideally Suited to Automotive Requirements

OVER THE YEARS, Chrysler has pioneered many applications for aluminum to the point where the average amount found in the Corporation's 1960 models is almost 65 lb. in 52 separate parts. The major reason for our interest, which has increased the use of aluminum from 9 lb. in 1947 to today's average, is to reduce weight of our cars, thereby increasing performance. The metal offers many possibilities for lower costs because it is readily adapted to the high-production, low-cost automation concept.

Of several fabricating processes for the light metals, die casting is ideally suited to automotive requirements. This process is fast, automatic, and produces parts that require only a minimum of finishing. Tolerances of 0.010 in. are common to die-cast parts and a high degree of intricacy and coring can be incorporated in the parts. For these reasons, we have concentrated on light metal parts fabricated by this method.

Considering only the applications now in use, the 65 lb. of aluminum now employed in our automobiles actually replaces about 250 lb. of iron and steel parts. Let us examine some of the recent typical applications.

Figure 1 shows a large integral transmission case and converter housing which weighs 21½ lb., as finish machined. This is a die casting made from A 380 aluminum alloy. The iron counterpart of this design, due to lack of coring and general section increase (as required by

*Chief Engineer, Materials Laboratories, Engineering Div., Chrysler Corp., Detroit.

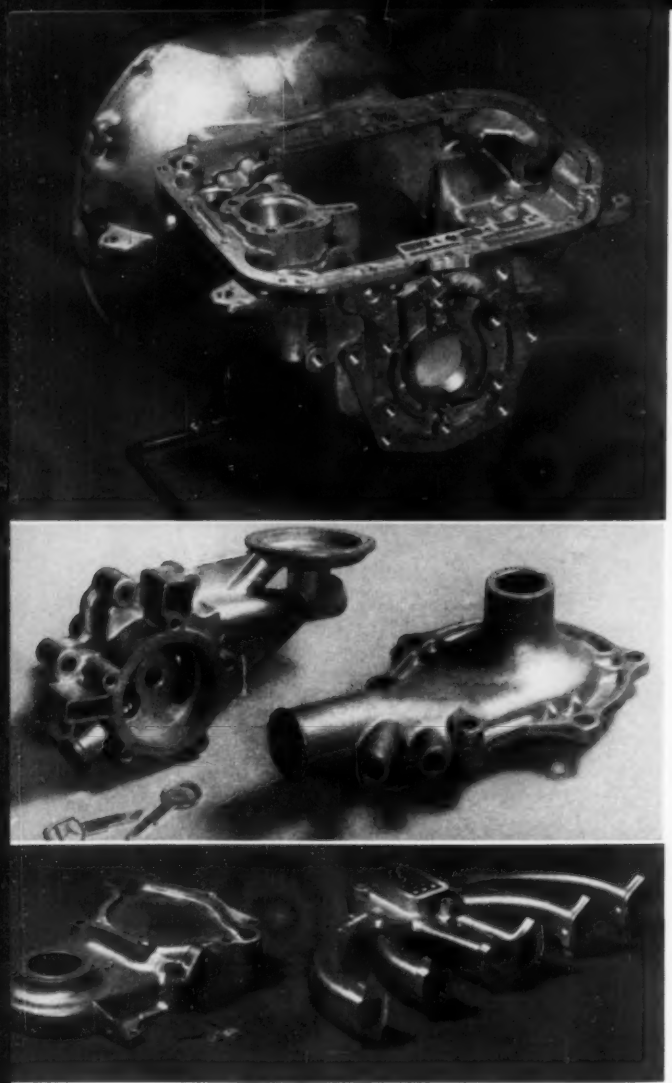


Fig. 1 – Aluminum Castings – Top Photo Shows Integral Transmission Case and Converter Housing Weighing 21½ lb., Die Cast From A 380 Alloy. The iron counterpart would weigh 90 lb. Center shows water pump (right) and oil pump housing also die cast of A 380. The chain case cover (at left bottom), a die casting weighing 4 lb., once was a cast iron part of 12.7 lb. The intake manifold also shown (right) is a semipermanent mold casting of AA 319 alloy

conventional iron sand foundry practice), would weigh 90 lb., rather than just three times the aluminum weight as would be expected from a comparison of specific gravities. With this in mind, it is evident that even at the most advantageous price for iron, the die casting could not fail to be economically attractive.

Machining Is Minimized – An added benefit was that the die-cast coring and close dimensional tolerances eliminated many machining operations which would normally be required on an iron casting. Also, it should be noted that we are presently incorporating the servo power-producing elements as a basic portion of this casting.

Also shown in Fig. 1 is a water pump and oil pump housing. Both parts are die castings, and again the alloy used is A 380. Historically, the automotive industry has used cast iron for water pump housings. However, our Valiant engine employs an aluminum die casting weighing only 1.2 lb.

We found that noise was no problem. So far as corrosion is concerned, the significant areas are those around the pump bearing, where the bosses connect, and all stagnant areas. Corrosion of aluminum is not uniform and progresses from a localized area in an intergranular fashion. Corrosion in this application is of the oxygen deficiency type and requires that all junction areas be coated with a corrosion resistant primer. Even though a brass seal was used in the aluminum housing, there was no evidence of detrimental galvanic corrosion in any of our tests. The oil pump housing weighs only 1.7 lb. with the filter base. Rotor shaft bore wear, as well as rotor face wear and scuffing, are controlled by specifying a surface finish of 25 to 50 micro-in.

The bottom photograph in Fig. 1 shows a chain case cover and intake manifold. The chain case cover was once a cast iron part, weighing 12.7 lb. The aluminum die casting of A 380 alloy weighs only 4 lb. In designing this casting, we took into consideration stresses caused by attachment to the block, those caused by pressing in the crankshaft seal, and operating stresses resulting from belt tension, rotating unbalance and water pressure. The area immediately behind the impeller is a stagnant water area and section thickness here was increased. Considerable development in gating techniques was needed to eliminate all the porosity from the water chamber wall because of the possibility of corrosion.

Permanent Mold Casting – The intake manifold is a semipermanent mold casting made from AA 319 alloy. This casting is pressure tight at 20 psi. It must have proper surface area and mass to transmit a regulated amount of heat to the incoming fuel mixture. The internal passages must be smooth to assure proper fuel distribution and to prevent accumulation of liquid fuel on the manifold floor.

Our compact Valiant is shown in Fig. 2, with all the aluminum parts used in it. It should be

Fig. 2 – The Valiant Compact Shown With All the Aluminum Parts Used in It

stated also that in many applications for aluminum castings we have found that magnesium is every bit as good.

Pearlitic Malleable Iron

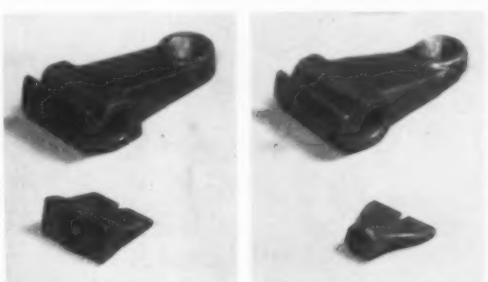
. . . Castings Replace Steel Forgings for Tough Jobs

Not all of our castings have been changed to light metals, and I would like to discuss some things we have done to make pearlitic malleable iron castings more attractive. Figure 3 shows the low and reverse band lever and kick-down anchor (smaller part) for our automatic transmissions. The band lever was formerly made from an S.A.E. 5150 steel forging. Machining included drilling the conical shaped plunger recess, broaching the band slot, milling the faces at the end of the shaft hole, and drilling this hole. Design of the part was modified slightly for casting; all essential details are cast into the part with the exception of the shaft hole.

After final heat treatment, castings are cleaned and reheated for hot coining. In this operation, the end faces at the shaft hole are sized and draft is eliminated. The conical recess and the band contact slot are coined to the desired surface finish and dimensions. The only machining then required is drilling of the shaft hole.

Hot Coining – The kick-down band anchor is another air quenched, pearlitic malleable iron part which replaced an S.A.E. 1065 steel forg-

Fig. 3 – The Larger Part is a Low and Reverse Band Lever Made in a Pearlitic Malleable Casting to Replace the S.A.E. 5150 Forging Shown at Right. The kick-down anchor (smaller part) is also a pearlitic malleable casting which replaced an S.A.E. 1065 forging (right)



ing. The part was originally machined, quenched and tempered to Rockwell C-50 minimum. Machining required drilling the adjusting stud hole, milling in the locating slot, and grinding the band contact surface. Now all essential details are cast into the part. After final tempering, the castings are merely cleaned and reheated for hot coining. Substantial savings were realized here by changes in material and by hot coining to bring these parts to final dimensions.

Cheaper Alloy Steels

. . . S.A.E. 4422 Replaces More Expensive S.A.E. 8620 in Many Applications

We constantly review our specifications, seeking out less costly materials in order to remain competitive. If there is another material which can be properly processed, satisfies the physical requirements, and results in a cost reduction, we try to use it.

This philosophy recently led to the development of a more economical steel for our rear axle drive pinions and ring gears. Formerly, we employed S.A.E. 8620 steel, which contains chromium, nickel and molybdenum as alloying elements, to make large passenger car pinions and certain truck ring gears, pinions, and side gears. The cost of this steel was high and we believed it was possible to develop a less expensive steel of comparable hardenability and machinability using only a single alloy. Our final choice, after careful consideration, was S.A.E. 4422 steel which contains molybdenum as the only alloying element present. The composition of S.A.E. 4422 is as follows: carbon 0.20 to 0.25%, manganese 0.70 to 0.90, phosphorus 0.040 max., sulphur 0.040 max., silicon 0.20 to 0.35, molybdenum 0.35 to 0.45.

Compares Well With S.A.E. 8620 – Hardening characteristics of S.A.E. 4422 steel are excellent, and not a single heat has caused any difficulty. The hardenability of S.A.E. 4422 is compared with S.A.E. 8620 in Fig. 4. Although hardenabilities are nearly the same, the molybdenum alloy steel tends toward the low side of the range. The machinability of forgings from S.A.E. 4422 has been found to be practically identical to that obtained when we were using S.A.E. 8620 steel for these applications.

Typical hardness traverses on a rear axle drive pinion gear are shown in Fig. 5. This is our method of determining whether the gear has been properly heat treated and it will also reflect differences in hardenability of the alloy. Distortion is no problem because excessive core hardness is not obtained with the alloy. Assemblies with components made from S.A.E. 4422 were thoroughly tested in both the laboratory and field prior to production. Results indicated

Fig. 4 – Hardenability of S.A.E. 4422 Compared With More Expensive S.A.E. 8620

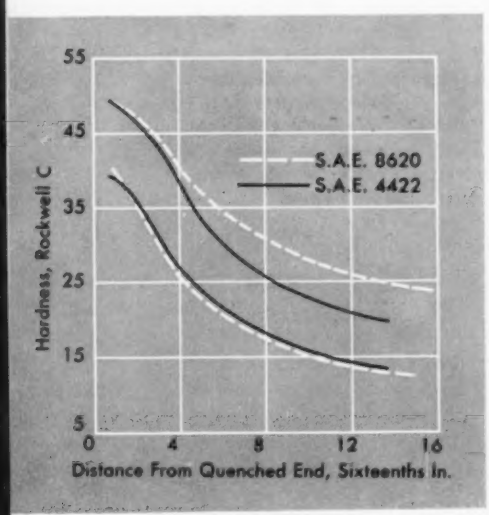
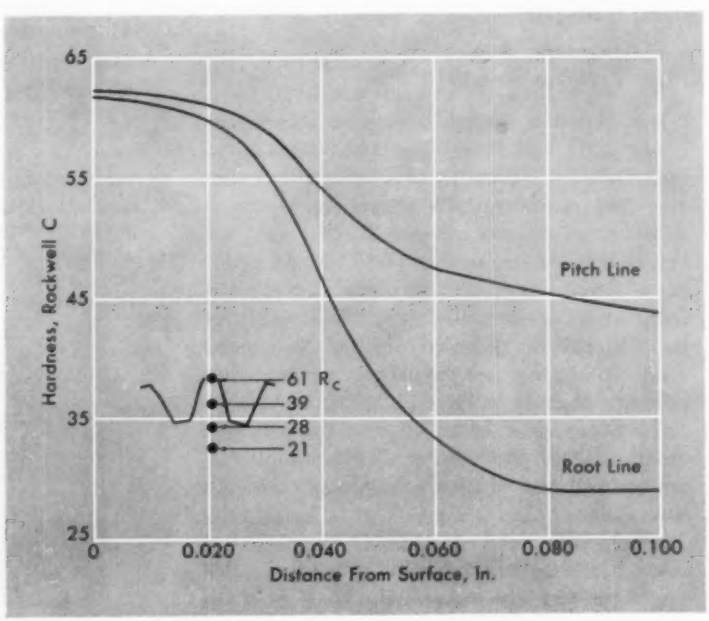


Fig. 5 – Typical Hardness Traverses on Rear Axle Drive Pinion Gear of S.A.E. 4422



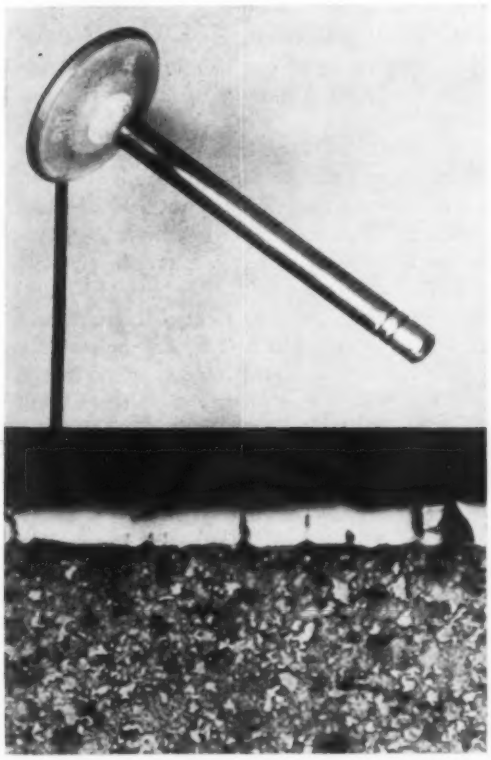
that the material's performance was equivalent to S.A.E. 8620 steel for these applications, and cost savings amounted to 40¢ per hundred weight.

Intake Valves

. . . Carbon Steel With Aluminized Coating Performs Well

Intake valves have, in the past, been fabricated from relatively expensive steels which inherently resist the environments encountered by these parts. However, since the valve, other than the face, is not exposed to severe conditions of heat and corrosive gases, it was felt that many steels having adequate strength could be employed for intake valves, if the valve face could be protected. Plain carbon steel (S.A.E. 1041) with an aluminum coating was found to be equivalent to Silcrome F for certain V-8 and 6-cylinder applications. An intake valve with a photomicrograph of the aluminized face is shown in Fig. 6.

Fig. 6 – S.A.E. 1041 Is Used for This Intake Valve to Replace More Highly Alloyed Steels. Photomicrograph shows aluminized face which protects steel from heat and corrosive gases



Extensive Tests Needed – Since radically different conditions exist in different engines, satisfactory performance of a valve material in one engine does not justify its release across-the-board for all engines. The specification of a material and process for a new engine is made only after exhaustive dynamometer and proving ground tests. The testing program before these valves were released covered a period of some three years of engine valuation and included 1½ million miles of endurance testing on the proving ground as well as 32,434 hr. in dynamometer engine tests.

Valves are aluminized today almost exclusively by the automatic version of the familiar metallizing technique. Simply stated, commercially pure aluminum is atomized and sprayed on the clean, preheated valve face. The only other necessary step is induction heating of the valve face at a temperature sufficient to diffuse the aluminum into the steel rapidly to the proper depth. This process gives a coating which is hard and the necessary wear and corrosion resistance to protect the valve face from hot engine exhaust gases.

Parts From Powder Metallurgy

. . . Iron Powder Mixed With Copper and Carbon Gives High-Strength Sinterings

For a number of components, we have found it economical to employ powdered metals. Examples are given in Fig. 7 and 8. Figure 7 shows the Valiant front clutch rear pressure plate (bottom) and the kick-down band lever used in automatic transmissions. The clutch plate is made by sintering a powder mixture of iron, carbon and copper to produce a steel part with 1% carbon and 2% copper. A grind on the flat side is the only finishing operation required. The piece weighs ½ lb.

The kick-down band lever (upper part in Fig. 7) is fabricated from the same material, but contains 5% copper. It, too, is used in the sintered or pearlitic condition and is substantially cheaper than the heat treated aluminum part previously employed.

The fan pulley hub (Fig. 8, top) is also sintered from a 5% copper-carbon-iron powder mixture and the microstructure is pearlitic. The part weighs slightly more than ⅓ lb. and it replaced

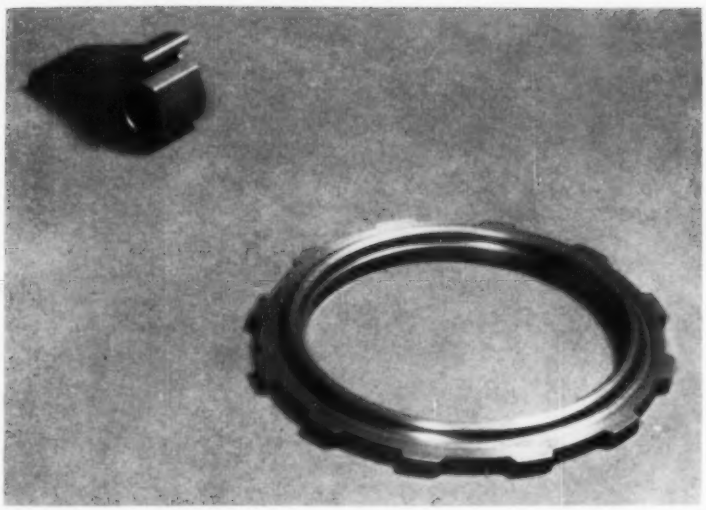


Fig. 7 – Lower Part in Above Photo Is a Valiant Clutch Plate Made by Sintering a Mixture of Iron, Carbon and Copper Powders to Produce a Steel Part With 1% C and 2% Cu. The kick-down band lever is also fabricated by powder metallurgy but contains 5% Cu. It replaced a heat treated aluminum part

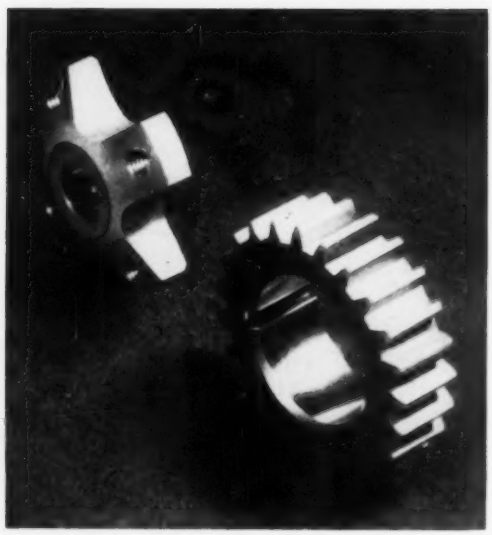


Fig. 8 – The Fan Pulley Hub (Top) Is Fabricated From a 5% Copper-Carbon-Iron Powder Mixture; It Has a Pearlitic Microstructure. The crankshaft sprocket contains only 2% Cu and is hardened to Rockwell C-59 min.

a machined gray iron casting. The fan, fan spacer, and fan pulley are attached to the hub by four bolts, and the hub, in turn, is attached to the water pump shaft by a press fit. Fan blade vibrations and overhanging pulley loads require substantial fatigue resistance in this part.

This Part Is Hardened – The crankshaft sprocket is fabricated from a 2% copper-carbon-iron powder mixture which is sintered and then hardened. The only other operation is grinding the internal diameter to tolerance of 0.001 in. and deburring the teeth after heat treatment. These sprockets are heat treated to produce a martensitic case which extends below the tooth's root and is about 0.120 in. deep at the tooth tip. The core structure is pearlitic; teeth have a surface hardness of Rockwell C-59 minimum. Previously these sprockets were machined from pearlitic malleable iron castings and the teeth were flame hardened.

Figure 9 gives typical stress-strain curves for powder metallurgy material in the parts discussed above. We have found that for normal

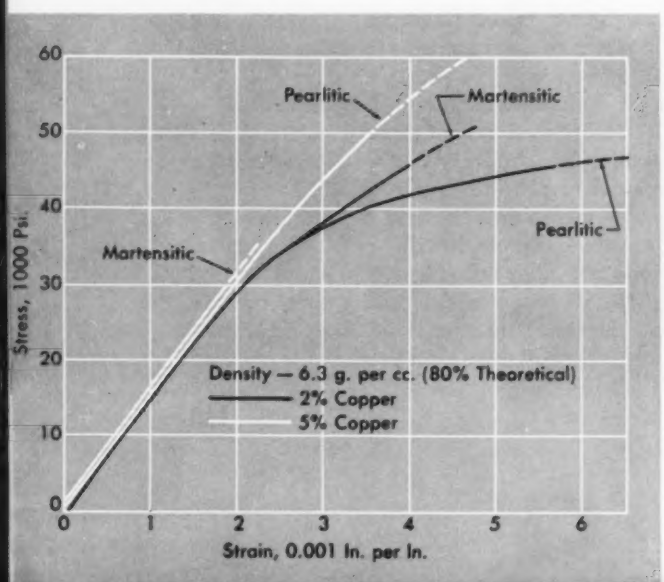


Fig. 9 – Typical Stress-Strain Curves for Parts Sintered From Iron Powder With 1% C and 2 and 8% Cu

structural applications, these materials have higher strengths for equivalent density than any other iron-copper compacts. Maximum strength is obtained from a 5% copper material in the "as sintered" condition. If wear resistance is required, then a 2% copper material is preferred, followed by hardening. The strength of these materials is primarily dependent upon the iron-carbon microstructure.

Cold Extrusion of Steels

. . . Permits Substitution of Cheaper Materials With Fewer Operations

One of the most important processes gaining popularity in the automotive industry is cold forging or cold extruding. Although the process is not new, technical advances in the past few years have made it increasingly attractive. Today, cold extruded parts are replacing many hot forgings and machined pieces. The process offers many advantages, which can result in attractive cost reductions:

- Excellent metal recovery results in substantial savings in materials.
- Finishing operations, such as machining, heat treating or grinding, can be reduced or eliminated.
- Cold working imparts high mechanical properties to the metal.
- The process gives smooth finishes, closer tolerances and uniformity of dimensions from part to part.
- Cold extrusion permits the substitution of more economical materials.

Now, to be realistic we must consider also a few limitations. Initial cost of capital equipment is high and must be considered when comparing the over-all cost of cold extrusion and other forming methods. Therefore, unless volume production can be maintained, capital expenditures may not be merited. In addition, tooling and maintenance can be quite expensive. There are, also, some material limitations. The very high alloy steels are still difficult to cold extrude without employing several stages with intermittent annealing.

At Chrysler, we have released many cold extruded parts to production within the past few years. An outstanding example of the advantages of cold extrusion is portrayed in Fig. 10. It illustrates the operations to produce the suspension control arm bushing by which we anchor the torsion bars. Formerly, this part was made from S.A.E. 1035 hot rolled bar stock. It was machined and bored on a screw machine. The hexagon-shaped hole was broached and the part was heat treated to produce the required physical properties.

Strength Comes From Cold Working – This part is now produced from S.A.E. 1021, spheroidized-annealed bar stock. The bars (2 3/32 in. in diameter) are cut into blanks 3½ in. long which are phosphate coated and then double-backward extruded in an automatic 500-ton horizontal press. This gives the finished shape, including the hexagonal hole. The only machining needed is to remove the web left in the center of the bushing and for the snap ring grooves on the end.

No heat treatment is required since cold working of the metal imparts adequate strength for service requirements. We obtain a hardness of Rockwell A-60 minimum measured on a

Fig 10 – Torsion Bar Anchor Extruded From S.A.E. 1021, Spheroidized-Annealed Bar Stock. It was formerly machined from S.A.E. 1035 hot rolled bars, then heat treated. Cost saving is 17¢ per part

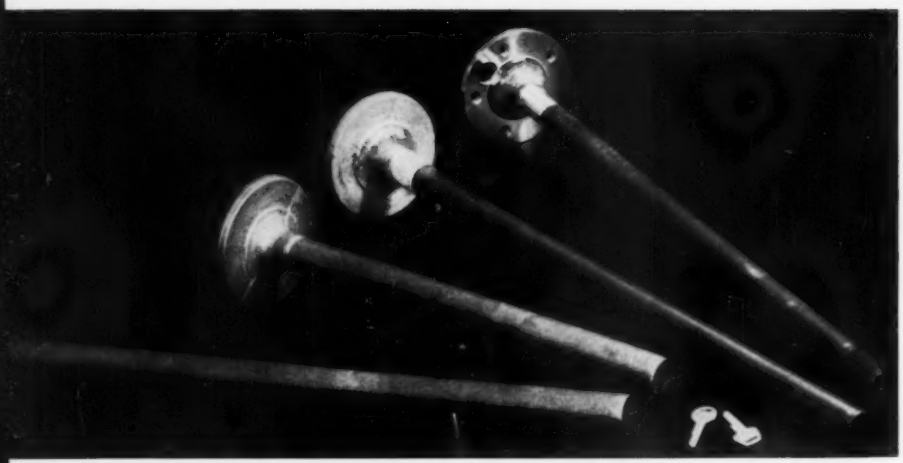


Fig. 11 – Axle Shafts for Valiant Are Fabricated by a Combination of Hot Forging and Cold Extrusion. S.A.E. 1039 steel is used

Fig. 12 – Main Transmission Shaft Is Cold Extruded From S.A.E. 1024 Steel Bars, 1⅝ in. Diameter, Cut to a Length of 15 In.

Fig. 13 – Hydraulic Steering Piston Extruded From Alloy Steel (S.A.E. 4023). Using a Slug Over 3 In. in Diameter

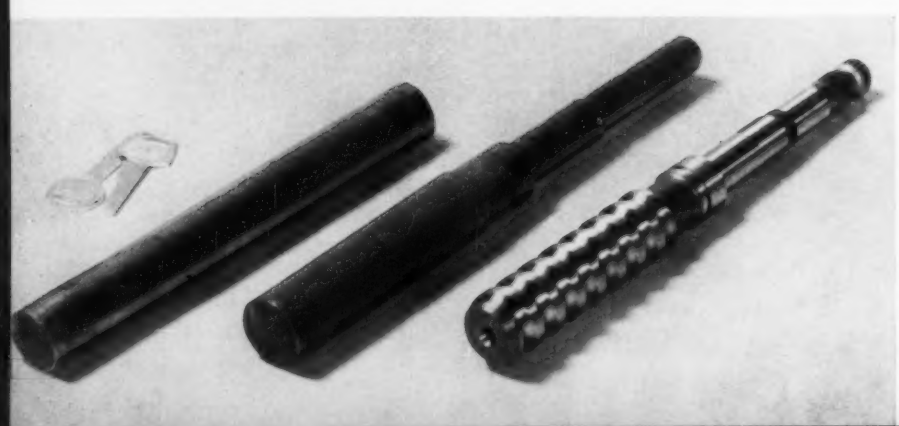


Fig. 14 – Hydraulic Steering Worm Made of S.A.E. 4027 Bar Stock Was Changed to Cold Extrusion to Reduce Machining Time

hexagon face 1 in. from the end. Additional advantages from cold extrusion of this part are: (*a*) the smaller amount of raw material needed for the part; (*b*) an increase in weldability resulting from the lower carbon steel. The cost saving for this cold extruded anchor amounted to 17¢ each.

Combination of Hot and Cold – It is sometimes advantageous to fabricate a part by both hot forging and cold extrusion. We produce axle shafts for the Valiant this way. The shaft is made from S.A.E. 1039 steel. The blank (Fig. 11) weighs 11.4 lb. and the flanged end is produced by hot forging. It is then normalized, cleaned by sand-blasting, washed and phosphate coated. The shaft is next cold extruded in a horizontal, three-stage, 175-ton press which is automatic. Next, the flange and the bearing diameter are partially machined and the spline is rolled. The part is then induction hardened and tempered after which the bearing diameter is finish ground and the flange is finish machined.

The main transmission shaft shown in Fig. 12 is cold extruded from 1⅝-in. diameter S.A.E. 1024 bar stock, cut to lengths of 15 in. These bars are shot-blasted to remove scale, washed and phosphate coated. Cold extrusion is performed on a 300-ton vertical, three-stage press which is hand-fed. The part is then machined, carburized and finished with a final grinding operation.

Our hydraulic steering piston (Fig. 13) is cold extruded from S.A.E. 4023 alloy steel bars, 3¼ in. in diameter. After shot-blasting and coating with a phosphate lubricant, the blank is fed into a vertical 1500-ton automatic press. The part is formed with both forward and backward extrusion in a series of stages which are required to move this large mass of metal.

Saves on Machining – The hydraulic steering worm in Fig. 14 is an example of a part configuration which lends itself readily to cold extrusion. Originally, this part was machined from S.A.E. 4028 bars. It is now being cold extruded from S.A.E. 4027 bars, 1 in. in diameter. This part was changed to cold extrusion for one reason: to reduce machining time. All the other operations – threading, heat treatment, and cutting the grooves – remain the same.

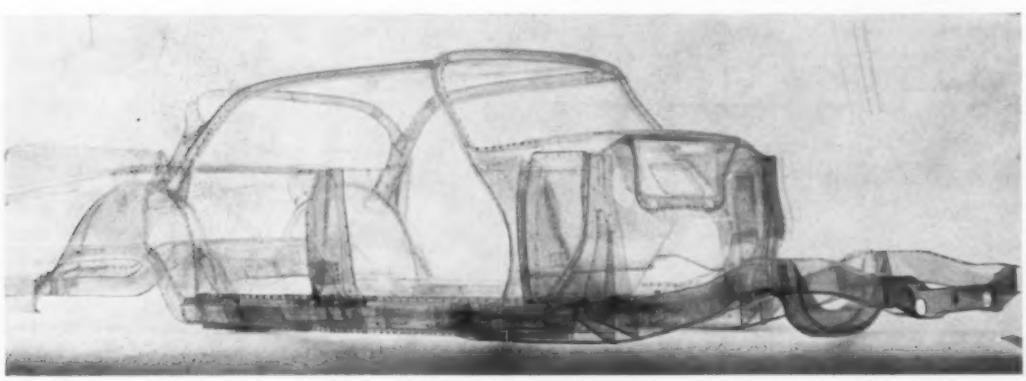
In each of the cold extruded parts the number of operations was reduced over what was required by other methods of fabrication. This has meant fewer quality control problems and has given us more parts per square foot of floor space. As more technical knowledge is obtained, cold extrusion will undoubtedly be adapted for many more parts where it is not now considered practical. Today, extruded parts are produced from steels such as S.A.E. 4130, 4340, 5150 and several stainless grades. To keep pace with the continued advancement of this process, steel mills will be required to produce steels of highest quality.

Resistance Welded Body

. . . A Rigid Structure Yet Flexible Enough to Withstand Stresses

The term "unit construction", as applied to automobiles, means having a stressed structure throughout, which is of composite design. It is opposed to the other major construction which

Fig. 15 – Plastic Replica of Unit Body. Stressed components are held together by resistance welding



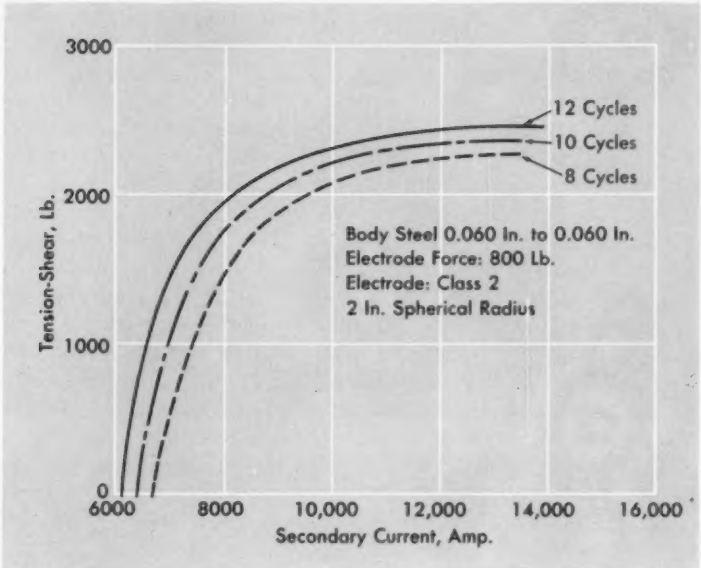


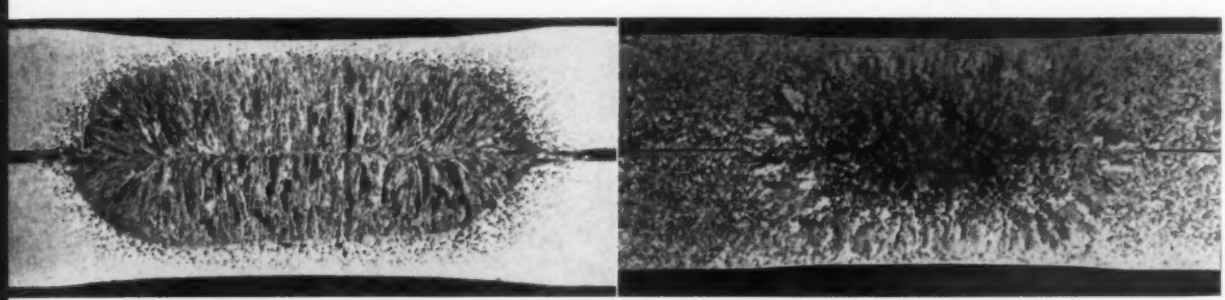
Fig. 16 – Typical Curves Developed to Define Welding Schedules to Meet Strength Requirements in the Unit Body. Curves show three different weld times

employs a superstructure or body mounted on a frame. In unit construction, which is illustrated by the plastic replica in Fig. 15, various stressed components are held together primarily by resistance welding. More than 7300 resistance welds and more than 450 in. of arc welding are required for each of our vehicles. The complex body shell uses 5200 resistance welds. They provide a vehicle that is rigid, yet flexible enough to withstand the stresses transmitted through the structure.

Weld Quality Holds Key – The ability of the automobile assembly to withstand service stresses depends on weld quality. This is related to many factors. Prior to Chrysler's adopting the unit body, welding guns and electronic controls were standardized, and electrical power and cooling water facilities had to be increased. Also, equipment and tooling revisions were required to meet the high welding standards specified. A corporate training program was initiated for all levels of manufacturing and maintenance personnel. Inspection methods, weld schedules and metallurgical requirements were defined in a process standard for each weld application.

Figure 16 illustrates only one of the family of curves developed to define schedules for welding the unit body. It covers conditions for welding steels, both 0.060 in. thick. Curves like this were devised for all gages from 0.030 in. to 0.120 in. thick. A series of curves such as this was used to establish strength requirements. Here, we varied only the time; we also have similar curves for variable force and current. To obtain these curves, thousands of coupons were examined to develop correct current, force and time to meet our welding

Fig. 17 – Cross Sections Show Satisfactory (Left) and Unsatisfactory (Right) Spot Welds



standards. Cross sectioning the welds established the fusion diameter and weld penetration. Figure 17 shows satisfactory and unsatisfactory welds. The fusion diameter is measured horizontally and weld penetration in the vertical plane.

A vehicle in motion imposes dynamic loads on welds which are directly related to nugget diameter and depth of fusion. To eliminate stick welds which might satisfy a test based on tension shear strength but fail to meet endurance requirements, nugget diameters and penetration are specified. Fusion diameter varies with the gage, while penetration is established at 20 to 90% of the metal thickness.

The production control department uses a "peel test" to determine weld quality in assemblies and subassemblies. This test reveals the nugget diameter and establishes the strength of the weld in comparison to the parent metal.

Protection Against Corrosion

. . . Underbody Areas Are Dipped After Assembly

Structural areas of the underbody in the unit construction method which required protection against corrosion were determined by a study of early prototype cars which were sectioned after extensive testing on salted and calcium-treated gravel roads at the Chrysler Proving Grounds. In addition, cars of unit construction already on the market were sectioned and examined after several years of service. These studies revealed that the top side of the floor pan inside the car and the

Fig. 18 — Bodies Are Immersed in a Water-Reducible Primer for Corrosion Protection. Front fenders are completely submerged

internal surfaces of body side sills are subjected to the most severely corrosive environment and require the best protection. Rear longitudinals, gussets and floor reinforcements were new structures requiring internal protection. Requirements to protect other surfaces were similar to our previous models.

Many methods of corrosion protection were considered for our unit body construction:

1. Sealed enclosed structural members.
2. Painting of internal surfaces with weld-through paints before assembly.
3. The use of galvanized steel, terne plate or a low-alloy corrosion resistant steel.
4. Spraying with paint after assembly.
5. Dipping in paint after assembly.

Painting underbody surfaces by dipping after assembly seemed to best satisfy the requirements of high quality and low cost, and appeared to have fewer production problems. It was adopted. Our past experience and early tests showed that maximum corrosion protection, using subsequent paint films, was obtained by cleaning and phosphate coating all metal surfaces. Our new process, thus, included cleaning and phosphate coating for both internal and external surfaces of the body structural members.

To achieve satisfactory cleaning for phosphate coating and to eliminate the need for conventional drawing compounds, this procedure was established: Steel blanks for structural members are cleaned prior to forming and then coated with a new, easily removable soap-type drawing compound. After welding of the stampings into the assembly, the body is cleaned and phosphate coated by a six-stage combination spray and immersion process. Bodies then go to the drying oven. The next step is coating of interior surfaces of the body side sills with water-reducible primer using a lance inserted into the sills. Coating of the side sills at this stage (while the bodies are hot) sets up the paint and prevents vapor wash-down inside the sills after dipping.

The third major step in the protection process is immersing of bodies in water-reducible primer to a depth of 16 to 17 in. at the door pillars (Fig. 18). Here, all areas requiring corrosion protection are coated with a water-reducible primer. Cars are tipped on entering and leaving the dip tank, so that the front fenders are completely submerged. The rear fenders are submerged above the trunk opening and about two-thirds of the rear fin is under the primer bath. The final step in corrosion protection is spraying of interior surfaces of body side sills with rust preventive wax. A lance is employed similar to that used for spraying the hot sills with water-reducible primer in a previous operation.

More Durable Plate for Bright Trim

. . . Duplex Nickel Coating Gives Four Times Longer Life Than Conventional Plate

In addition to providing cars which will remain free from rust during their normal life, we are also striving to improve the appearance and lengthen the life of exterior bright trim. One outstanding advance is adoption of the duplex nickel plating process. It consists of plating exterior steel trim parts first with a little more than 0.001 in. of semibright nickel followed by about one-half this thickness of bright nickel. For optimum results, the ratio of bright nickel to total plate thickness should be 3 to 1.

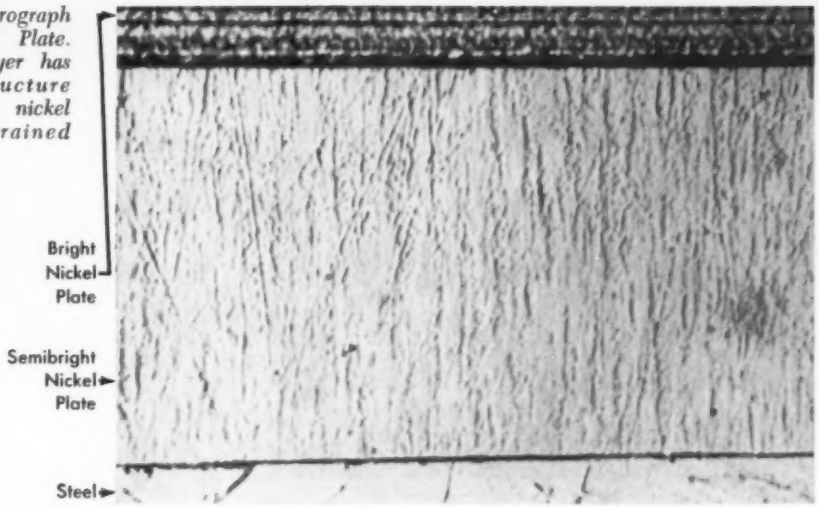
In plating zinc die castings, this ratio changes to 2 to 1. However, castings after buffing and cleaning require an initial copper plate 0.0003 in. thick. The copper coating is needed primarily for adhesion of the nickel plate, although it also provides additional corrosion protection.

An electroplate of duplex nickel applied to a steel part is shown in the photomicrograph in Fig. 19. The lower portion is the steel, the next band upward is semibright nickel, and the third band is bright nickel. A thin coating of chromium is plated over the nickel.

Difference in Structures – The advantages of this type of plate are many. As shown in Fig. 19, the semibright nickel plate has a columnar structure, with preferred orientation, and possesses maximum ductility. On the other hand, if used alone this coating would require buffing for the required luster. The bright nickel is extremely fine grained, has a random orientation; it has a bright luster, so buffing is not required prior to chromium plating. It is, however, brittle, compared to semibright nickel, and its corrosion resistance is not as good.

The duplex nickel, being made up of two layers, also, in effect, forms a porosity barrier since the likelihood of any pores in the bright nickel exactly lining up with pores in the semibright layer is extremely remote. Also, the semibright nickel contains no sulphur because it is plated from a bath which is free from brighteners based on organic sulphur com-

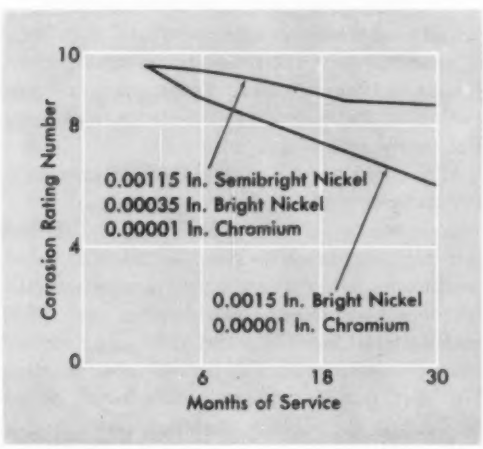
Fig. 19 – Photomicrograph of Duplex Nickel Plate. The semibright layer has a columnar structure while the bright nickel layer is fine grained



pounds. An electrochemical potential thus exists between the sulphur-containing bright upper layer and the semibright sulphur-free under layer. This offers some sacrificial protection since the bright layer gives anodic protection to the under layer.

Benefits from duplex nickel plating of bright work are summarized in Fig. 20. It is based on data from production parts in over 1200 cars in service in the Detroit area. Since the curve is a geometric progression, it does not show dramatically the tremendous difference in protection offered by the duplex nickel plate compared with a plate of bright nickel of equivalent thickness. Actually, it can be shown that a duplex plate of a given thickness has four times the life of a plate of equal thickness produced by older plating systems.

Fig. 20 – Corrosion Data on Bright Plated Parts on 1200 Cars in Detroit Area Show Superiority of Duplex Nickel Process. Rating of 10 indicates no corrosion



Better Paint Finish

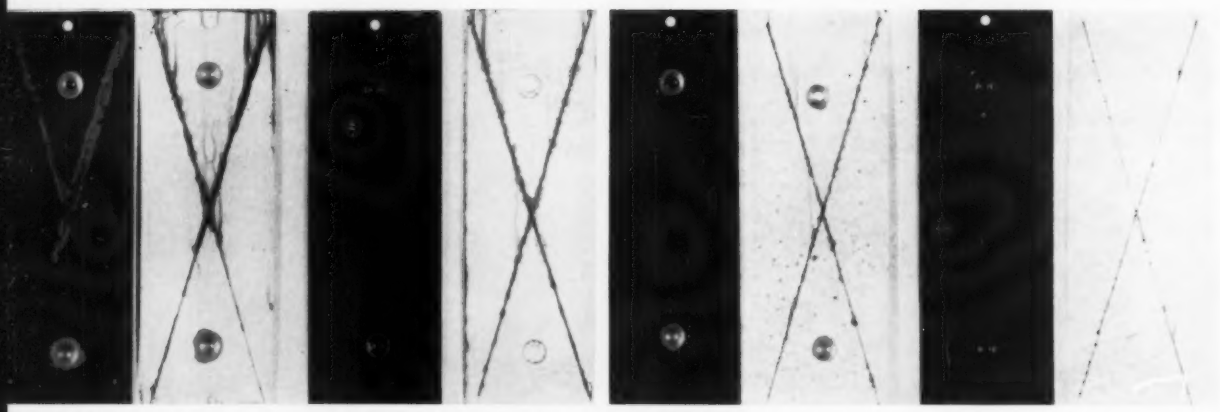
. . . Improved Enamel and Epoxy Primer Give High Luster and Greater Durability

Automakers are always interested in improved enameling systems. An important advance is the nonoxidizing alkyd resins produced by condensation of poly-basic acids and poly-hydric alcohols to give a new resin vehicle – the coconut oil alkyd. This permits higher melamine content in exterior body enamels with many advantages over previous finishes.

Greater hiding power and less "orange peel" are characteristics of this new enamel. Films have greater durability and more resistance to yellowing and dulling. The new enamel has also permitted the use of pastel colors of high metallic content for the first time.

Epoxy Primer – The improved color coat was paralleled by the equally important development of better primers. These are the epoxy resins. Their main advantages are extreme chemical resistance, adhesion to a wide variety of surfaces, and excellent flexibility, particularly at lower temperatures. The permeability of films of epoxy resins to moisture is very low.

The improved performance of the epoxy primer compared with a previously used alkyd



Old Primer Surface *New Epoxy Primer Surface* *Old Primer Surface* *New Epoxy Primer Surface*

Fig. 21 – The Improved Performance of New Epoxy Primer Is Reflected by These Salt Spray (Left) and Humidity (Right) Test Panels. Impact resistance is evaluated after panel has been out of test chamber for 24 hr.

resin primer is illustrated by results of salt spray and humidity cabinet tests shown in Fig. 21. The atmosphere in the humidity chamber is maintained at 100° F. with a relative humidity of 100%. Impact resistance of the coating is evaluated after the panel has been out of the test chamber for 24 hr.

For salt spray evaluation, panels are placed in a 100° F. salt spray chamber (5% sodium chloride solution) at an angle of 15° from the vertical. After being exposed for 250 hr., the panels are removed, and given an impact test in the same manner as for humidity evaluation.

Polymers for Auto Parts

. . . New Plastics and Heat Resistant Rubber Expand Applications

Synthetic organic polymers – plastics, rubbers and fibers – are of interest to the materials people in the automobile industry. A significant point is that the price trend in plastics is toward lower prices, whereas the cost of metals indicates an upward trend. Also a substantial improvement in thermoplastic compounds has taken place within the last few years. Most of the thermoplastics available up to 1957 had only limited heat stability. Even boiling water brought about distortion. The newer polyethylenes, polypropylenes, Penton, Delrin and Lexan extend the useful applications of plastics up to 340° F.

One example of an excellent application for plastics is the radio speaker grille in Fig. 22. Originally produced as a die cast part, these grilles were later designed as painted metal stampings. We have accumulated sufficient knowledge so that the part is now made in polypropylene. The toughness of the material is shown in the bent part at left in the figure.

Additional advantages are offered by the means available for attaching the grilles. Two flat lugs on one side are inserted into rectangular holes of the sheet metal instrument panel, moved to the left, and then two snap-in buttons on the right are simply pushed into their contoured receiving holes in the instrument panel. There are similar applications for this material in numerous interior trim parts.

Needle Valves – Another recent application for polymers is the resilient tip for carburetor needle valves. Although there are two filters in the fuel system, the possibility exists that dirt particles may wedge between the metal tip of the carburetor needle valve and the brass valve seat. Any dirt prevents the needle from making a complete seal, thereby resulting in carburetor flooding, excessive fuel consumption and faulty operation.

About two years ago, Du Pont announced a new polymer, Viton A (a copolymer of hexafluorpropylene and vinylidenefluoride). It has very high resistance to swell in aromatic fuels, good room-temperature aging properties and excellent resistance to compression set. This new material, used as the valve tip, greatly increases the tolerance of needle valves to dirt. Any dirt particles temporarily embed themselves into the rubbery material, permitting a

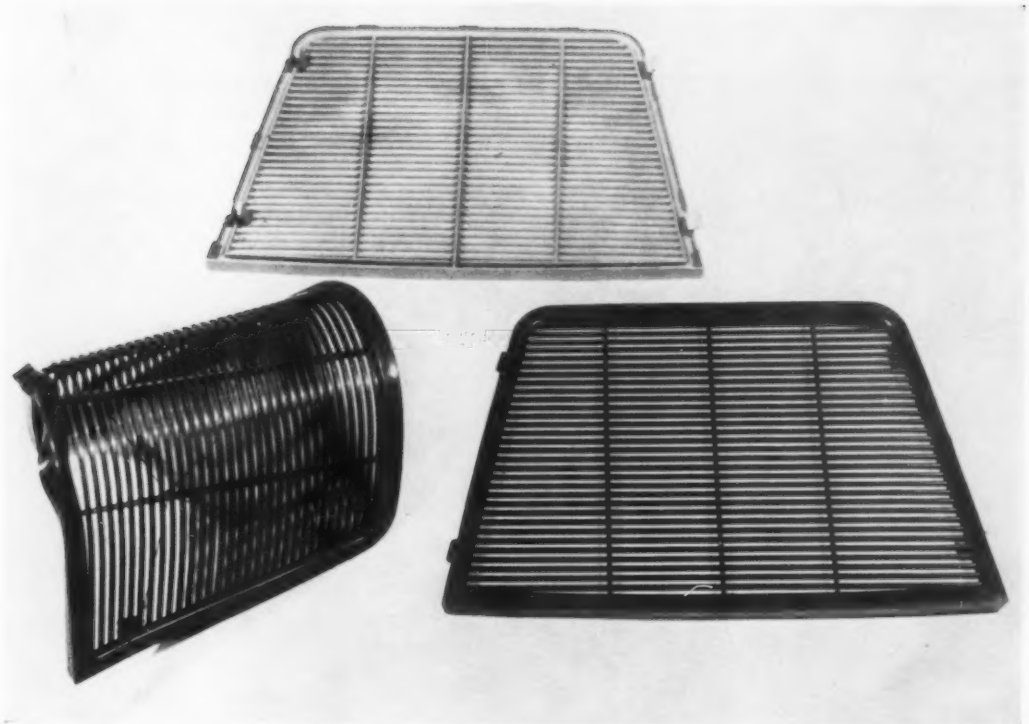


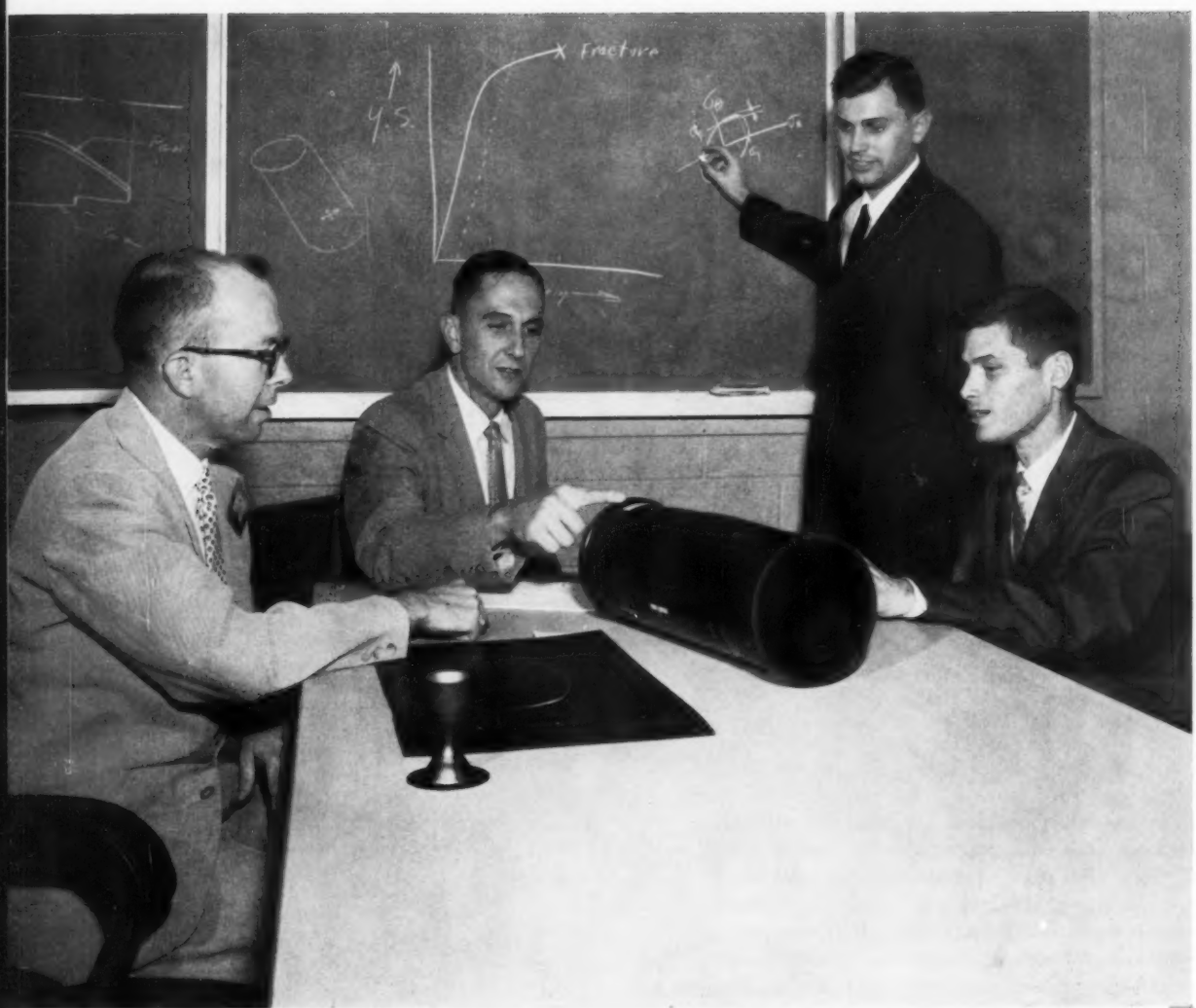
Fig. 22 – This Radio Speaker Grille Made of Polypropylene Plastic Replaced a Painted Metal Stamping. Its toughness is indicated by bent part at left

Fig. 23 – Spark Plug Cover of Silicone Rubber (Top) Stands up Well to Engine Heat Compared With Previously Used Neoprene Rubber Covers

continued perfect seal. When the valve is opened, the fuel washes the tip free of dirt.

Heat Resistant Rubber – Since automotive stylists have lowered car hoods and engine horsepower has been increased, temperatures under the hood have risen to a point where spark plug covers formerly made of neoprene are now unsatisfactory. Measurements made at our Arizona proving ground have shown that spark plug covers reach 350° F. and more. At this temperature, neoprene becomes hard and loses its rubber-like properties within a few hours. The answer to this problem was silicone rubber (Fig. 23).

In addition to excellent high-temperature resistance, the silicone spark plug covers provide high-voltage electrical insulation, excellent resistance to compressive set with good low-temperature flexibility and resistance to oil, water and ozone. To avoid the strong tendency of the silicone covers to adhere to the ceramic spark plug bodies, powdered silica is used as a dry lubricant.



Technical Management at Work – (From left to right) E. S. Jones, manager, alloy studies unit of metallurgical engineering, and L. P. Jahnke, manager, metallurgical engineering, Flight Propulsion Laboratory Dept., General Electric Co., discuss the merits of various materials for construction of rocket cases and nozzles with A. E. Ketler and R. Viventi, G. E. design engineers. The strident demands by the builders of solid propellant rockets – they want superstrength up to 400° F. for rocket cases and a modicum of structural strength at 4000 to 6000° F. for nozzles – have in large part been the impetus back of recent advances in high-temperature metallurgy at the low and high ends of the temperature scale.

A Report to
Technical Management

Updating High-Temperature Metallurgy

*By E. S. JONES and L. P. JAHNKE**

Since 1958, there has been much progress in the field of high-temperature alloys, particularly at the two ends of the temperature scale. Between room temperature and 500° F., "Ausformed" steels hold the most promise, while tungsten is suitable for temperatures above 3000° F. Titanium alloys, cold worked nickel alloys, and molybdenum and columbium alloys are also improving the high-temperature picture. (Q-general, 2-62; SGA-h)

BACK IN NOVEMBER AND DECEMBER 1958, *Metal Progress* presented articles which gave an account of the status of high-temperature, high-strength alloys. Since that time, much progress has been made in several sectors of elevated temperatures—progress even surprising to men who have been deeply involved in the struggle.

To illustrate, Fig. 1 shows the tensile strength-temperature curves of the "best" 1958 alloys as compared with those now available. As is apparent, most of the advances (the shaded areas) have occurred at the low and high ends of the temperature scale.

What is back of this pattern? Frankly, it is largely the result of strident demands by the builders of solid propellant rockets – they have been crying for superstrength at 0 to 400° F. (for propellant cases) and for a modicum of structural strength at 4000 to 6000° F. (for nozzles). Similarly, there has been a demand for structural metals useful at 2000 to 2500° F. for a variety of applications such as glide re-entry, ramjets and nuclear power generation. Here, progress is also evident. And nowhere does it seem that still further advancement will be stopped by impenetrable barriers.

To outline these advances, we have numbered these segments in Fig. 1, each of which represents a situation of significance. These are:

1. "Ausforming" of martensitic steels
2. Beta titanium alloy development
3. Cold worked nickel-base superalloys
4. The apparent stagnation of the nickel-cobalt superalloys
5. The rapid growth in columbium alloys
6. The emergence of tungsten as a structural metal

Ausforming of Martensitic Steels

Of the variety of metallurgical advances in the field of high-strength steels, none possesses more exciting ramifications than the Ausforming process, a treatment which requires heavy (50

*Manager, Alloy Studies Unit, and Manager, Metallurgical Engineering, Flight Propulsion Laboratory Dept., General Electric Co., Cincinnati, Ohio.

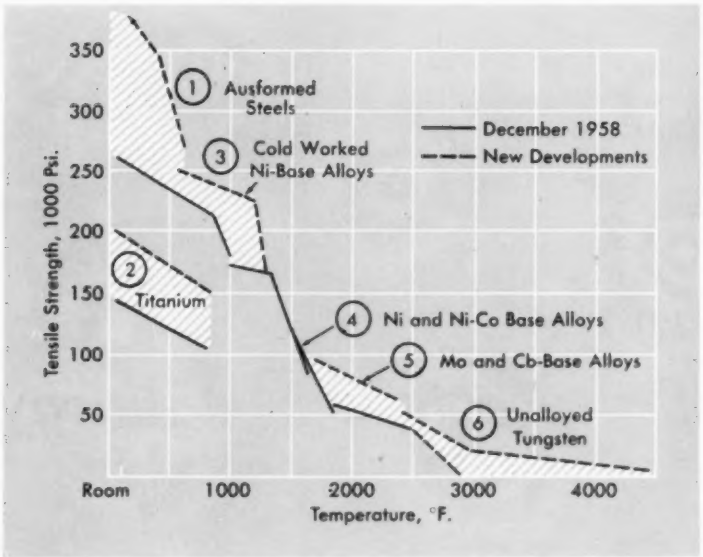


Fig. 1 – Advances in the Field of High-Temperature Alloys Since 1958. Note that most of the progress has occurred at the low and high ends of the temperature scale. Each of the six categories is discussed in the text

to 90%) deformation of a normally martensitic steel while it is still in the austenitic condition. As described in *Metal Progress* (September 1959, p. 66), this entails forming above the M_s temperature. Best results are obtainable only through isothermally deforming special steels; precise knowledge and control of the transformation kinetics are also needed.

Without lengthy discussion, the strengthening is thought to result from two factors: strain hardening of transformation products, and refinement of the martensitic needle size. Much better strength-ductility balances have been obtained than by conventional heat treatment, and strengths as high as 400,000 psi. with low, but possibly usable, ductility have been documented. The warm deformation (usually at 700 to 1000° F.) presents monumental manufacturing problems if one wishes to make thin-walled pressure vessels, but it is safe to assume that ways will be found to do this. For instance, compositions which are Ausformable at 100 to 200° F. have already been identified.

The Ausforming concept has just begun to grow, and will probably spread in many directions in the next few years. However, strength advantages are rapidly lost as "use temperatures" rise. At 700° F., little or no advantage remains over heat treatable martensitic steels.

Beta Titanium Alloys

Steel and titanium are still running a mercilessly competitive race for the highest strength-to-weight ratios in the 0 to 1000° F. range. Neither attains an advantage for long, and neither has a grip on all the applications at any one time. Steel's low cost and the corrosion resistance of titanium are among the formidable weapons each possesses against the other.

Late in 1958, the new "all-beta" titanium alloys were announced; since then they have been generally accepted. Among the best of these is Crucible's B 120 VCA (see *Metal Progress*, December 1959, p. 119). Containing 13% V, 11% Cr, and 3% Al, it has a stable beta microstructure at room temperature. Aging the beta structure at 700 to 1100° F. precipitates alpha and $TiCr_2$ compound, with resultant strengthening. Yield strengths of 180,000 to 200,000 psi. may be achieved by prolonged aging treatments, and cold work plus aging can result in even higher strengths (but at the expense of ductility).

The combination of cold workability, weldability and high yield strength makes the beta titanium alloys top contenders for applications requiring the highest possible strength-to-density ratios. Furthermore, the cost of titanium alloys ($4 to $5 per lb. of billet) has now decreased to the point where they are more competitive with vacuum melted steels, especially compared on a volume per dollar basis.

Cold Worked Nickel-Base Superalloys

Cold working the precipitation-strengthened nickel-base alloys (Inconel "X", René 41 and

Why metals corrode...and how you can prevent it

The basic cause of corrosion is the instability of metals in their refined state. Metals tend to revert to their natural states through the processes of corrosion. For example, when you analyze rust, you will find it is iron oxide. When you analyze natural iron ore, you find it, too, is iron oxide. Six forms of corrosion which can attack the equipment you design are:

1. General tarnishing or rusting with occasional perforations in highly affected areas.

2. Highly localized attack by pitting.

3. Cracking induced by a combination of stress and corrosion.

4. Corrosion confined to crevices, under gaskets, or washers, or in sockets.

5. Corrosion of one of an alloy's constituents leaving a weak residue.

6. Corrosion near the junction of two different metals.

In all of the six forms of corrosion mentioned above, corrosion has the same basic mechanism. It's similar to the electrochemical action in a dry cell.

The electrolyte in the dry cell corresponds to the corrosive media, which may be anything from the moisture in the air to the strongest alkali or acid.

The plates of the battery correspond to the metal involved in corrosion.

A potential difference between these metals or different areas on the same metal causes electricity to flow between them through the electrolyte and a metallic bridge or contact that completes the circuit.

At the anode, a destructive alteration or eating away of metal occurs when the positively charged atoms of metal detach from the solid surface and enter the solution as ions.

The corresponding negative charges, in the form of electrons, travel through the metal, through the metallic bridge, to the cathode.

Briefly then, for corrosion to occur, there must first be a difference in potential between the metals or areas on the same piece of metal so that electricity will flow between them. Next, a release of electrons at the anode and a formation of metal ions through disintegration of metal at the anode. At the cathode, there must be a simultaneous acceptance of electrons. Action at the anode cannot go on alone, nor can action at the cathode.

CONTROLLING CORROSION

When corrosion occurs because of the differences in electrical potential of dissimilar metals, it is known as galvanic action. Differences in potential from point to point on a single metal surface causes corrosion known as local action.

When you plan against galvanic corrosion it is essential to know which metal in the couple will suffer accelerated corrosion . . . will act as the anode in the corrosion reaction.

The galvanic series table shown below can supply this information. In any couple, the metal near the top of this series will be the anode and suffer accelerated corrosion in a galvanic couple. The one nearer the bottom will be the cathode and remain free from attack or may corrode at a much slower rate.

GALVANIC SERIES TABLE

Magnesium
Magnesium alloys
•
Zinc
•
Aluminum 25
•
Cadmium
•
Aluminum 17ST
•
Steel or Iron, Cast Iron
•
Chromium-iron (active)
•
Ni-Resist
•
18-8 Stainless (active)
18-8-3 Stainless (active)
•
Lead-tin solders
Lead, Tin
•
Nickel (active)
Inconel* (active)
•
Brasses, Copper, Bronzes
Copper-nickel alloys, Monel *
•
Silver solder
•
Nickel (passive)
Inconel (passive)
•
Chromium-iron (passive)
18-8 Stainless (passive)
18-8-3 Stainless (passive)
•
Silver
•
Graphite, Gold, Platinum

HOW TO USE THE CHART

Notice how the metals are grouped in the galvanic series table. Any metal in one group can be safely used with any other metal in the same group. However, when you start mixing metals from different groups, you may run into serious galvanic corrosion of the metal higher on the list. And the further apart these metals are listed, the worse this corrosion may be.

But, if you have to mix metals, pay particular attention to the electrical contact between them. Eliminate any metallic bridges or contacts of metal to metal that will permit the flow of electrons through them. You can do this by separating the metals physically, or by using insulation or protective coatings. Another factor is the relative areas of the metals in contact with each other. Parts having the smaller area should be of a metal with a lower listing on the galvanic series table than the metal used for the larger area.

When you plan against local action, remember that the corrosion process is galvanic: Electrons move from one point in the metal to another. One of the easiest ways to prevent local action is to use a metal with little or no impurity. When alloys are involved, make sure the constituents are closely listed in the galvanic series table. Local action may also be stopped by the use of protective coatings, which shield the metal from the corrosive media. Environment must also be considered, for its nature may be an important factor in either promoting or restricting corrosion.

TECHNICAL ASSISTANCE

As you can see, many factors are involved in both local and galvanic action. That's why it's best to bring your metal problem to Inco's Corrosion Engineering Service. Available data will be furnished wherever possible . . . tests will be made where needed. Inco's Corrosion Engineering Service will be glad to apply principles of corrosion control to your specific problem.

LITERATURE

The publications listed below will provide more detailed information on how you can combat corrosion by using nickel-containing metals.

Publication Number	Name
A232 . . .	Corrosion Problems in Nuclear Reactor Power Stations
A59	Factors of Importance in the Atmospheric Corrosion Testing of Low-Alloy Steels
A62	A Theory of the Mechanism of Rusting of Low-Alloy Steel in the Atmosphere
A137 . . .	Corrosion by Some Organic Acids and Related Compounds
A144 . . .	Some Observations of the Potentials of Stainless Steels in Flowing Sea Water

A complete list of the 187 Inco publications and technical bulletins on nickel-containing metals can be obtained by writing for "List A", to:

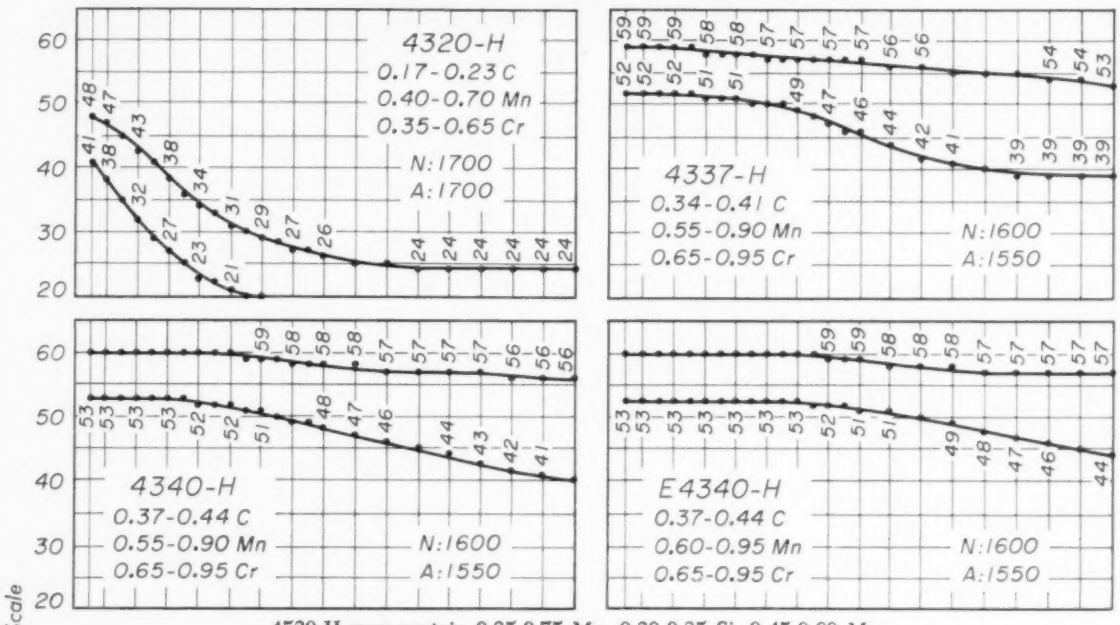
*Registered trademark

The INTERNATIONAL NICKEL COMPANY, Inc.
67 Wall Street INCO New York 5, N.Y.

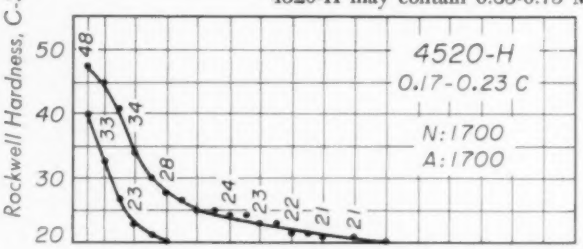
Circle 1714 on Page 48-B

Hardenability Bands for Steels 4320-H to 4718-H

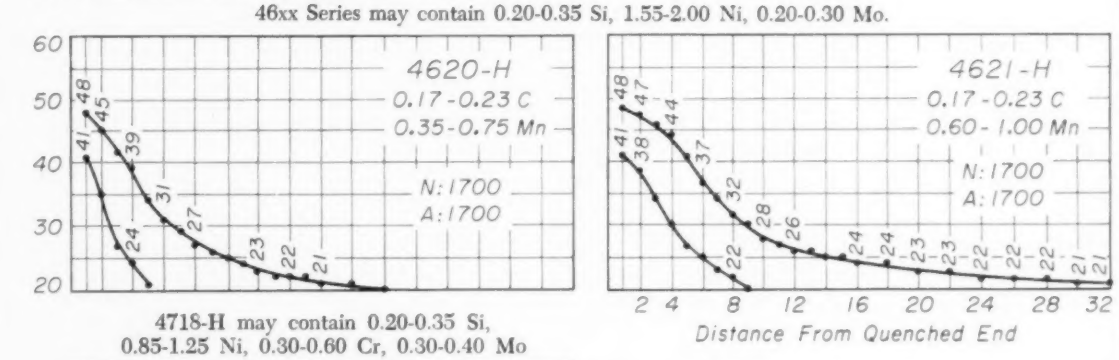
43xx-H Series may contain 0.20-0.35 Si, 1.55-2.00 Ni, 0.20-0.30 Mo



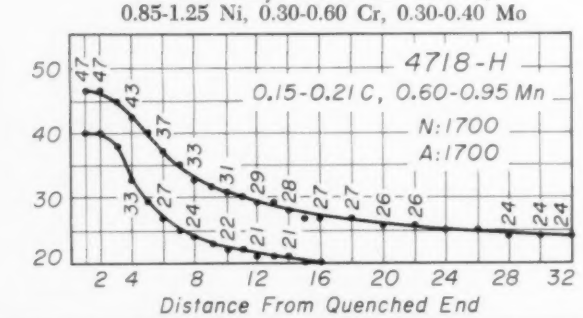
4520-H may contain 0.35-0.75 Mn, 0.20-0.35 Si, 0-45-0.60 Mo



46xx Series may contain 0.20-0.35 Si, 1.55-2.00 Ni, 0.20-0.30 Mo.



4718-H may contain 0.20-0.35 Si, 0.85-1.25 Ni, 0.30-0.60 Cr, 0.30-0.40 Mo



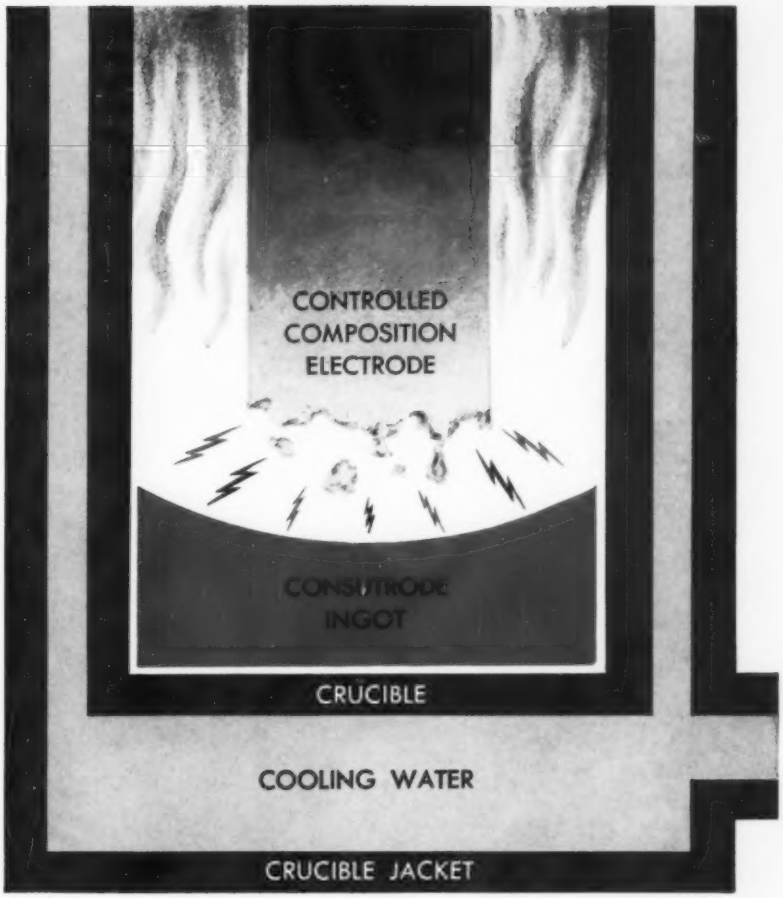
Rockwell Hardness, C-Scale

N means normalizing temperature for forged or rolled material; A means austenitizing temperature (both as recommended by S.A.E.).

Hardness limits are specified in Rockwell C-scale units (no fractions) and can be scaled from the plotted points where not labeled at even sixteenths.

A.I.S.I., February 1960

Vacuum Melting Extracts Impurities



Improved soundness, better hot and cold workability, higher mechanical properties, cleaner metal with lower gas content—these are the characteristics of vacuum melted steels from Allegheny Ludlum.

Typical of the metals produced by vacuum melting are Consutrode® steels and alloys. They provide outstanding cleanliness and homogeneity at minimum cost. These alloys, pioneered by Allegheny Ludlum, are available in the largest ingot sizes of any vacuum melting process—up to 20,000 lb. ingots. This makes possible larger products of high quality in super alloys, stainless, tool, and low alloy steels.

Consutrode alloys are made by vacuum remelting electrodes of a predetermined composition by an electric arc. The white heat of the arc—8000 F—breaks down many nonmetallics in the electrode. Considerable degasification, as well as substantial improvement in cleanliness, is achieved by the furnace vacuum which removes the oxides and nitrides released in melting of the electrode.

Controlled solidification of the molten metal in a water-cooled crucible is a principal advantage of the consumable electrode vacuum process. This gives an exceptionally sound and homogeneous ingot.

Other recently developed methods for improving steels and properties of the improved alloys are described in a new booklet, "Modern Melting at Allegheny Ludlum." It includes a description of Special Air Melted Steels, Invac alloys made by induction vacuum melting, Invacutrode alloys made by remelting Invac electrode stock by the consumable electrode vacuum process, and Consutrode alloys.

This new booklet is packed full of charts and graphs—a real help to anyone who must get the most out of metals. Ask your A-L representative for a copy or write: ***Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pennsylvania. Address Dept.*** *MP-10.*

ALLEGHENY LUDLUM

PIONEERING on the Horizons of Steel

2116

Circle 1715 on Page 48-B

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... Blue Ribbon Award Winners, 1959 A.S.M. Metallographic Exhibit

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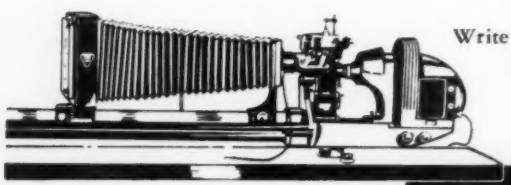

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others of this class) is very effective for achieving high strengths in the 600 to 1200° F. range. When the solution-treated structure is cold worked, the coherent $Ni_3(Al, Ti)$ phase precipitates on slip planes and as a fine dispersion in the matrix. When other alloying elements are also included (for greater thermal stability), this precipitate appears to retard dislocation movement, even at quite high temperatures. Stress-rupture strength at 1200° F. has been bettered by 20 to 25% in certain alloys such as J-406, a new General Electric composition.

However, above 1300° F., recovery and recrystallization effectively restrict use of the cold worked alloys at higher temperatures. Then alloys such as U-700, Inco 713, and others are stronger, and are used in solution treated and aged condition.

Manufacturing methods which take advantage of strengthening through cold work will allow fabrication of components with the highest available tensile and creep strengths at moderate temperatures. In this field, hopes are high; more progress is expected in the next few years.

Ni-Co Superalloys Appear at a Standstill

Over the range from 1200 to 1800° F. there has been insignificant progress. This temperature region, by far the most active in the decade just past, is now filled with dozens of excellent alloys, primarily of the nickel or nickel-cobalt base type. Intensive efforts have brought about two situations: First, there is now a dearth of good ideas on how to proceed further. The second (and more important) is that the alloys which finally evolved from this great effort are so exacting in their composition, so difficult to process, form, weld and braze, that a great deal of attention has gone into solving their *problems* or in finding substitute alloys which are less troublesome. Most laboratories have now stopped striving for the small advances that everyone finally recognizes are all that are likely to come without a remarkable breakthrough.

Thus the nickel, nickel-cobalt, and cobalt-based alloys, having served us admirably for years (and always to be supreme in this temperature range), have nearly completed their moments of development excitement. Until some remarkable ideas are forthcoming, efforts in this field will be toward the worth-while but less exciting task of bettering process methods, cutting costs, exacting small strength advances, and balancing strength, ductility, cost and fabrication ease. (This is, of course, the ultimate destiny of any high-temperature alloy system, and each will face it in its turn.)

Rapid Growth of Columbium Alloys

For temperatures above those which can be reached by nickel and cobalt alloys, molybdenum has long been the hope of the materials engineer. However, there is still no *producible* alloy which exceeds the strength levels of the molybdenum-titanium-zirconium alloys at 1800 to 2500° F. The exciting thing that has happened in this temperature range is the rapid development of columbium alloys which not only compete in strength with molybdenum alloys, but are also more attractive in oxidation resistance, nuclear properties, and over-all fabricability and low-temperature ductility.

The discovery of large columbium ore deposits in the mid 1950's started the full-scale development of alloys, and several laboratories are now striving hard to improve alloys in this system. Quite a few metallurgists believe that

Fig. 2 – This Turbine Rotor for a Jet Engine Has Been Forged From René 41, a Nickel-Base Alloy. The "as-forged" inner surface is unusually smooth, thus reducing final machining costs. This rotor weighs 117 lb. and is 22 in. long. (Photos Courtesy Wyman-Gordon Corp.)

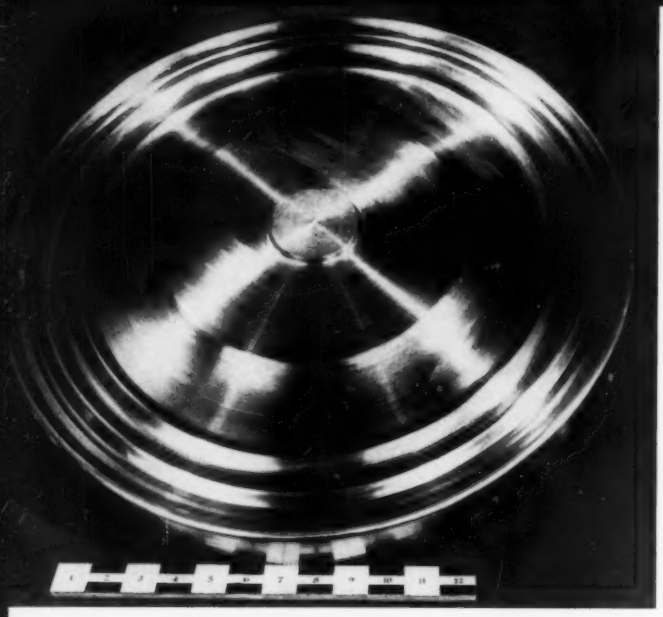


Fig. 3 – This Turbine Wheel Is Made of Astroloy, a Nickel-Base Alloy With Excellent Tensile Strength and Stress-Rupture Properties at Elevated Temperatures. The wheel is 22 in. in diameter and weighs 170 lb.

columbium will win the competition with molybdenum for 1800 to 2500° F. applications. Since this covers the bulk of the next generation of high-temperature requirements (nuclear power, atmosphere glide re-entry, turbo-jets, high-Mach ramjets), the prize is a good one.

The strongest alloy which has reached a pilot production stage of development is General Electric's F 48, but still stronger compositions are in the offing. Recent articles in *Metal Progress* (June and July 1960) gave a fairly thorough report on the status of columbium alloys, so this need not be described here. It is enough to say that their primary drawback is a susceptibility to embrittlement caused by the solution of oxygen at the surface either during processing or during use. To counteract this, their forte is a generally higher level of ductility and oxidation resistance than can be achieved with the other plentiful refractory metals. They are still not adequately resistant to oxidation above 1800° F. (protective coatings are needed), but the results of coating failure are not catastrophic as with molybdenum.

The Emergence of Tungsten

The right-hand portion of Fig. 1 (above 2400° F.) could not be described in 1958 simply because no reliable data on strength had yet been obtained. Such information is now available, due primarily to fine work by the N.A.S.A. The data shown are for commercially pure tungsten produced by powder metallurgy techniques. The significance of these data is that, for the first time in tungsten's long existence, it is being developed as a structural metal.

Much of the current effort on tungsten is for application in uncooled rocket nozzles and for leading edges of glide re-entry vehicles. This requires strengths, shapes, sizes and ductility far beyond former demands. Few doubt, however, that it will be supreme among the metals for high strengths above 3000° F.

Processing problems are the first and most imposing barrier; the melting point and the extreme strength of the simplest alloys tax the temperature capabilities of the finest facilities in the country. (This same limitation is also faced now by the strongest columbium and molybdenum alloys and is a real deterrent to progress.) A second problem, that of poor ductility at low (below 700° F.) temperatures, should be solved by concerted alloy development efforts.

Today, most pure tungsten and tungsten alloys are being prepared by powder metallurgical methods. It is probable that this method of consolidation will always be favored and will be gradually adopted by the molybdenum and columbium producers also – for reasons of economical processing if not for reasons of wider vistas for compositional development.

Already a tungsten alloy with a strength of 60,000 psi. at 3000° F. has been identified, and this is merely a beginning. The enormous art behind the development of "doped" powder metallurgical tungsten and "non-sag" lamp filaments will contribute greatly to rapid progress in the high-strength field and probably reveal new possibilities in the other refractory metals.

Other Areas of Promise

This article would not be complete without brief references to other pieces of significant progress in the high-temperature, high-strength field. With chromium, for example, recent work has shown that great inroads on the ductility problem have been made, and that alloys with good 2000° F. strength and excellent oxidation resistance can be developed. It is quite possible that chromium-based alloys will fill the 1800 to 2100° F. gap between nickel and columbium. The next two years should show us.

As for tantalum, though it is much more scarce (and thus costlier) than the "big three" of refractory metals, columbium, molybdenum and tungsten, it is still a very attractive metal. There is much promise for high-strength, duc-

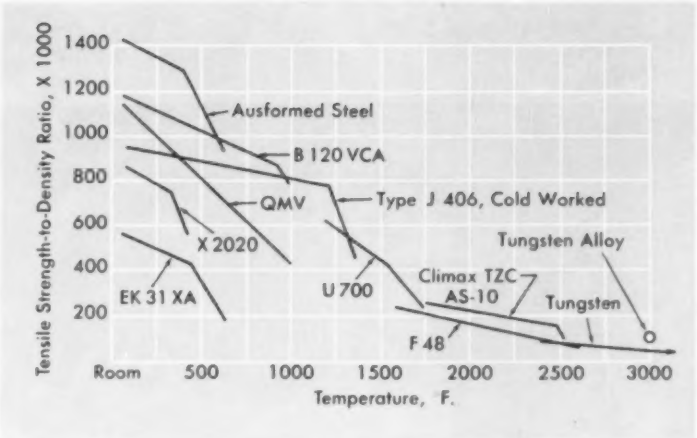


Fig. 4 – Strength-to-Density Ratios of Several Alloys. Aluminum, magnesium and beryllium, respectively, provide the bases for X 2020, EK-31 XA and QMV; bases for the other alloys are mentioned in the text

tile alloys. It is quite possible that tantalum will answer several specific needs throughout the 2400 to 5000° F. range, in applications where its good fabricability can be used to advantage. However, where weight is a limiting factor, its high density will make it difficult for the metal to compete with columbium or molybdenum unless *very strong* alloys are developed.

Much development effort is now being directed toward studies of the physical metallurgy and fabrication of beryllium. Its low density, combined with a modulus of over 40×10^6 psi., makes this metal a potential answer to the designer's dream. Poor ductility remains one of the more stubborn problems hindering increased use of the material. However, good progress is reported, and methods will doubtless be found to minimize or eliminate the ductility problem, making it and its alloys strong strength-to-weight competitors up to 1000° F.

Lastly, nonmetallics have possibilities. Blushingly, it must be admitted that laminated plastics may eventually surpass the strength-to-weight ratios of the best high-strength steels in the 0 to 300° F. range. And for temperatures above 5000° F., pyrolytic graphite is a good bet to be stronger than tungsten and better suited for certain applications.

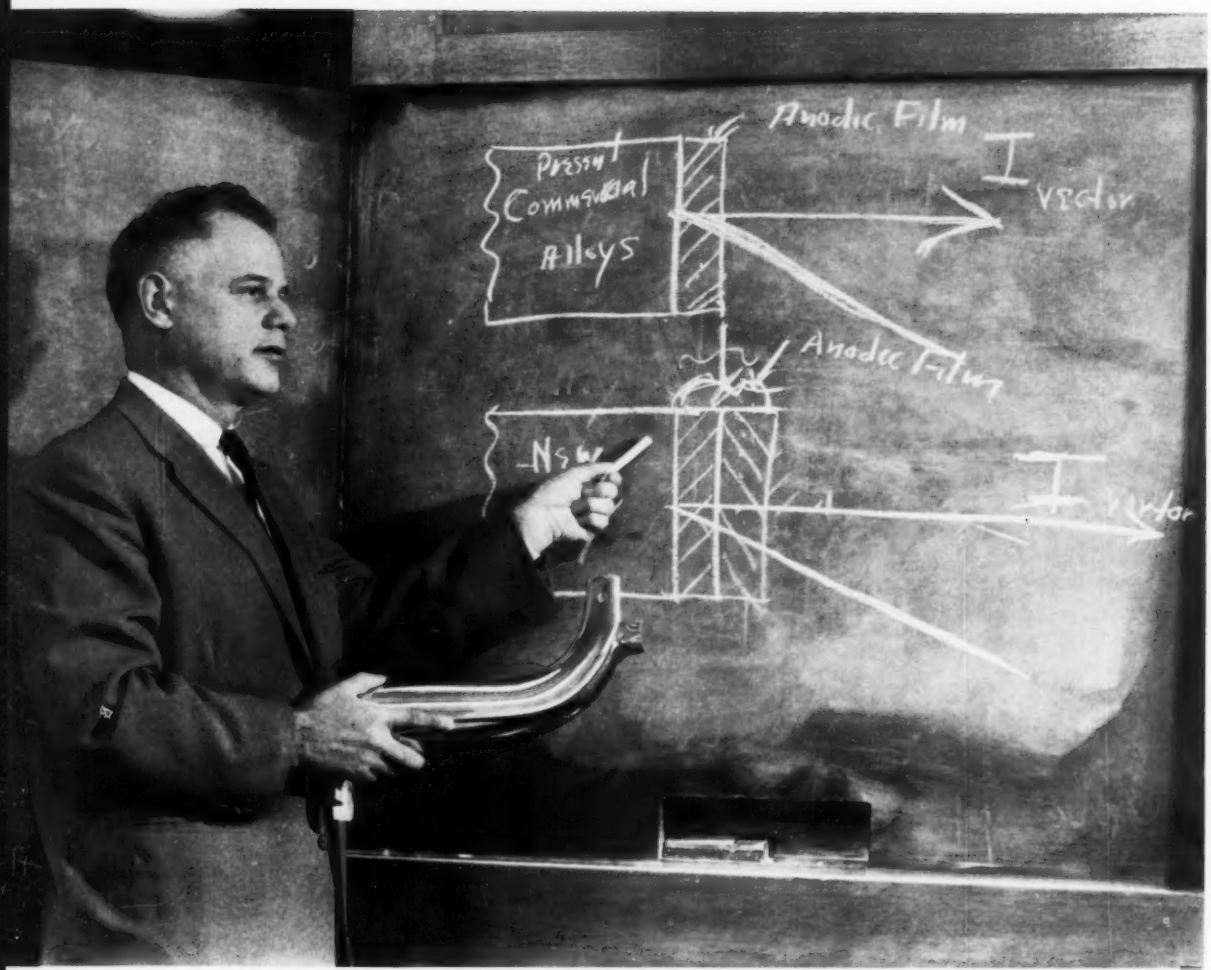
Where We Stand Today

Figure 4 presents an over-all view of the strength-to-density relationships of various metals and alloys over a wide range of temperatures. Perhaps the most striking feature is the large difference in strength-to-density ratios at the extremes of the temperature scale. Lightweight structures that have characterized designs for applications up to 800 to 1000° F. would not appear possible for 2000° F. and above. Another point of interest is the relatively small group of materials that compose the "magic million" club (those with strength-to-density ratios over 1,000,000). At the moment, only Ausformed steels, beta titanium and beryllium are in this category.

A final point concerns the relative positions of alloys usable at 2000° F. and above. Columbium and molybdenum alloys compete closely for the top spot, until above 2700 to 2800° F., when tungsten assumes the strength advantage. The rapid development of tungsten alloys will probably allow them to compete on a strength-to-density basis at still lower temperatures.

The next few years should see a continuing improvement in the strength-to-density ratios in the 2000 to 3000° F. range, especially since refractory alloy development is relatively "young" compared to the superalloys of nickel and cobalt, and alloy steels.

From all of this evolves a pattern which has only recently been perceived because of the relative youth of high-temperature metallurgical activity. The pattern is this – all of the reasonably plentiful metals have their roles to play. Each has its temperature range for most efficient use; each goes through the same cycle of discovery, development, application, maturing and optimization; and each must fiercely compete for a place in man's creations. It will be interesting to review and compare our predictions today with actual applications in the 1970's, when the developments of the present decade will be history, and attack on new materials frontiers will have started.



Technical Management at Work – John English, chief metallurgist at Reynolds Metals Co.'s McCook, Ill., sheet and plate plant, explains how 5657 aluminum alloy is much brighter than present alloys with the same or even twice the amount of protective anodizing. The new alloy will have many applications in automobiles and appliances.

A Report to
Technical Management

*Progress in Aluminum Alloys**

New alloys and improved techniques, such as plaster core and vacuum die casting, enable parts to be cast which have better physical properties and a brighter surface . . . New wrought alloys have better weldability . . . APM products provide increased corrosion resistance in severe environments . . . New alloys in 5000 series give brighter finishes . . . Unusual patterns for architectural and other trim applications will come from rolling of composite alloys. (A-general; Al-b, 17-57)

MORE MANUFACTURERS are turning to aluminum castings to reduce costs and improve their products. A switch to cast aluminum parts is particularly effective in reducing machining time, cutting down on shipping weight, and lowering finishing costs. Examples are the deep-groove design on the cast aluminum rollers shown in Fig. 1, which boosted operating efficiency of a flexible loading conveyer made by the Power-Curve Conveyor Co.

New casting methods are being applied to produce rocket tube cases with mechanical properties comparable to the wrought product. In the heat treated condition, cases machined to a ⅛-in. wall thickness have exhibited a tensile strength of 80,000 psi., with short transverse (across the wall) elongations better than a comparable wrought product. Employing the plaster core technique, a contoured head can be cast integrally with the cylindrical shell. With another casting trick Alcoa die casts a bearing mount with the "oil-less" bearing cast in place.

More structural applications are being found for the standard casting alloys. Ford is planning to make 1961 transmission cases as die castings because of lower *over-all* costs. The "design integration" – all manufacturing steps combined in one operation – afforded by the die-casting process can result in some rather substantial savings. The cast stair tread shown in Fig. 2 is an example of a well-designed structural part produced economically.

Vacuum Die Casting Improves Product

A die-casting process (developed by Nelmor Mfg. Corp.) produces thin-section, high-purity aluminum parts which are uniformly dense and free of porosity and oxide. Compared to conventionally die-cast aluminum parts, these castings have better corrosion resistance and show a 15 to 20% improvement in electrical conductivity. After anodizing, they exhibit a bright, permanently lustrous finish – reflectivity exceeds that of good chromium plate. The castings are ductile, so they can be cold formed. They can also be joined by arc welding without creating a porous weld, since entrapped gases have been eliminated.

The success of vacuum die casting depends

*The editors acknowledge the help of the following in preparing this Staff Report:

Aluminium Laboratories Limited, Kingston, Ont.
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Aluminum Smelters Research Institute, Chicago
American Smelting & Refining Co., New York
Apex Smelting Co., Cleveland
Harvey Aluminum Inc., Torrance, Calif.
Kaiser Aluminum & Chemical Corp., Oakland, Calif.
Nelmor Mfg. Corp., Cleveland
Olin Mathieson Chemical Corp., New York
Reed-Prentice, East Longmeadow, Mass.
Reynolds Metals Co., Richmond, Va.

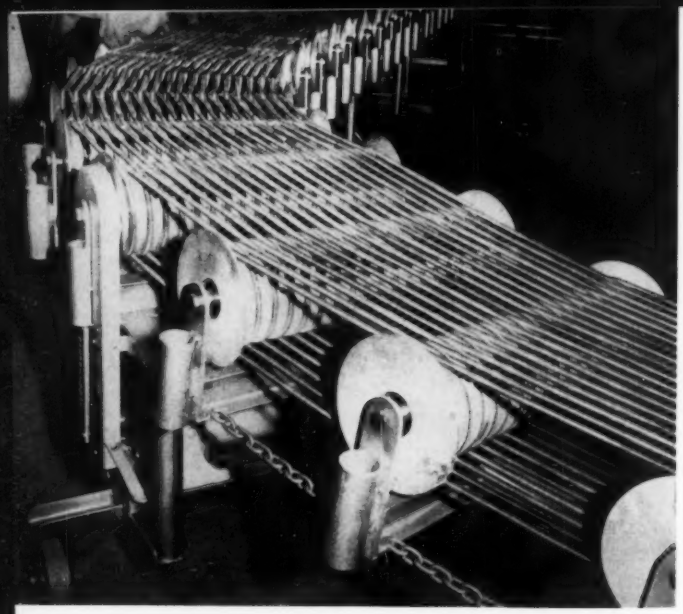


Fig. 1 – Cast Aluminum Rollers Used in Flexible Conveyer. Deep grooves keep the spring belts securely in place, insuring smooth operation

on three factors: (*a*) quality and purity of pig charge, (*b*) care taken in melting – employing three-compartment, radiant-fired gas furnaces*, and (*c*) a vacuum-transfer system which eliminates hand ladling and prevents oxide formation. Figure 3 illustrates the vacuum transfer and automatic ladling arrangement on a die-casting machine.

A new "fluidized plastic" coating is being applied by dipping hot die castings into a plastic powder. The coating is thick enough (0.015 in.) to cover minor surface defects; it also gives a "warm" feeling to the metallic part. Alcoa's "Shad-O-Wheel", the decorative solar screening system shown in Fig. 4, is composed of these plastic-coated die castings.

Alloy Control for Better Cast Products

To improve aluminum castings, specification changes covering mechanical properties, alloying elements, and impurity limits are being studied. The industry feels that mechanical properties should be determined on test bars cut from the castings at designated locations and not from separately cast test bars. Properties are affected by castings conditions as well as by composition of the alloy.

For improved shock resistance the Aluminum Association is recommending, and the Federal Bureau of Public Roads has accepted, a specification for roadway railing posts (cast in permanent molds) which calls for a reduction in iron content of 356 alloy from 0.5 to 0.2%. Integrally cast test coupons are also specified. This guarantees a tensile strength of 25,000 psi. (min.) and an elongation of 6% (min.) in the T 6 temper, as opposed to a permissible elongation value of 3% in separately cast coupons of standard 356-T 6 alloy. (The elongation could be as low as 0.75% in test bars cut from castings and it would still pass the old specification.)

As another example, the permissible zinc content of die-casting alloy SC 84 A (8.5% Si, 3.5% Cu) has been raised from 1 to 3% by Committee B-6 of the American Society for Testing Materials. The higher zinc limit improves the machining and casting characteristics of the alloy and at the same time reduces its price.

The high-temperature strength of aluminum-magnesium casting alloys is increased by adding special nucleants for grain refinement, reports Aluminium Laboratories Limited. Carbon tetrachloride is introduced into the melt via a preheated carrier gas, preferably nitrogen. Since aluminum-magnesium alloys are used in making cylinder heads for air-cooled engines, this news is important to the auto industry.

Aluminum-iron-nickel alloys can withstand the corrosive environment of high-purity water and steam at 680° F. One composition in par-

Fig. 2 – One-Piece Die-Cast Stair Tread. Note the slip-proof nose section, made of fused Al_2O_3 particles, which is metallurgically bonded to the casting

*A furnace of this type has been developed by Kozma Furnace Co.

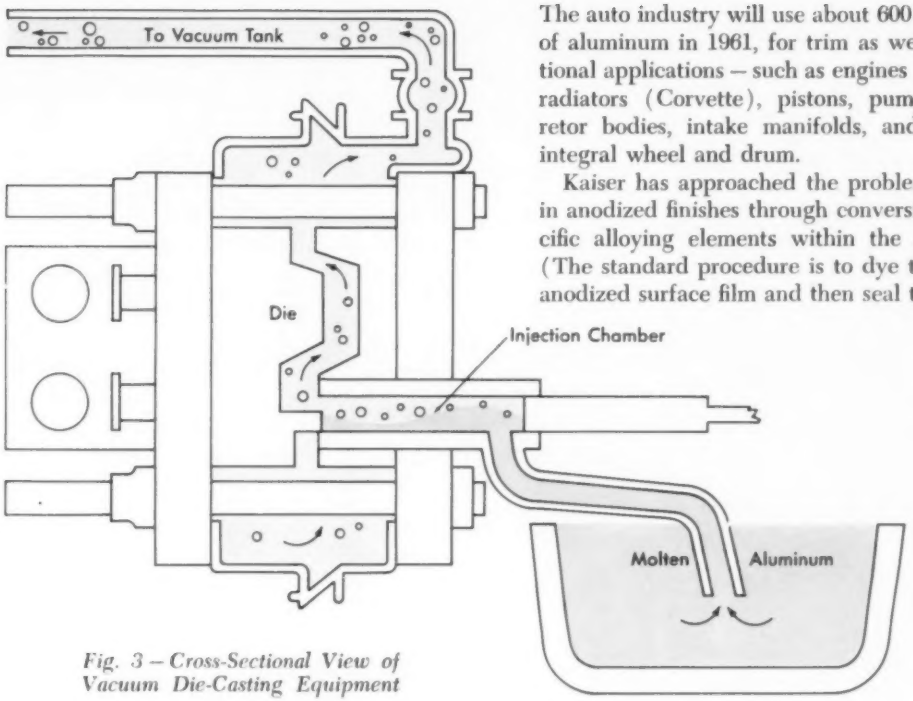


Fig. 3 – Cross-Sectional View of Vacuum Die-Casting Equipment

ticular – an APM (powder metallurgy) product containing 4.8% Fe and 7% Ni – holds promise for cladding uranium fuel rods in the next generation of atomic reactors designed for increased power output.

Emphasis Is on Finishing

Continuing work on alloying and anodizing techniques is at last yielding a finish for 5757 alloy which looks almost like chromium plate – the ultimate in trim appearance according to automobile designers. Alcoa states that the finish is achieved by (*a*) controlling the impurity content of 5757 alloy, (*b*) buffing and bright dipping the part to remove a layer of contaminated metal, and (*c*) anodizing under controlled conditions. Just as in any other process, conversion-coating procedures must be constantly checked to insure a satisfactory finish. Alloy 5757 has the formability and strength required for automobile bumper applications and can be used for other trim requirements, such as grilles, wheel covers, and bezels.

The automobile industry is testing aluminum bumpers, and the possibility exists that as many as four 1961 model cars will have them. Total aluminum trim on U.S. cars has increased from 17 million lb. in 1956 to 55 million lb. in 1959. The auto industry will use about 600 million lb. of aluminum in 1961, for trim as well as functional applications – such as engines (Corvair), radiators (Corvette), pistons, pumps, carburetor bodies, intake manifolds, and Pontiac's integral wheel and drum.

Kaiser has approached the problem of color in anodized finishes through conversion of specific alloying elements within the aluminum. (The standard procedure is to dye the porous, anodized surface film and then seal the colored coating.) The Kaiser technique achieves a high degree of color stability and uniformity. Available colors include gold, amber, tan, brown, olive, gray and black. At the present time, the "Kalcolor" process is applied only to architectural extrusions and sheet for use in commercial construction.

For automobile bumpers Kaiser has developed a new series of heat treatable alloys with adequate strength and good ductility. A special

Fig. 4 – Decorative Sun Shield Is Assembled From Plastic-Coated Die Castings

Fig. 5 – Duplex Nickel-Chromium Plate Applied to Bumpers Made From New Heat Treatable Alloy. Major auto manufacturers are now conducting road tests on prototypes

chromium plating process for bumpers and trim – duplex nickel-chromium – produces the results pictured in Fig. 5.

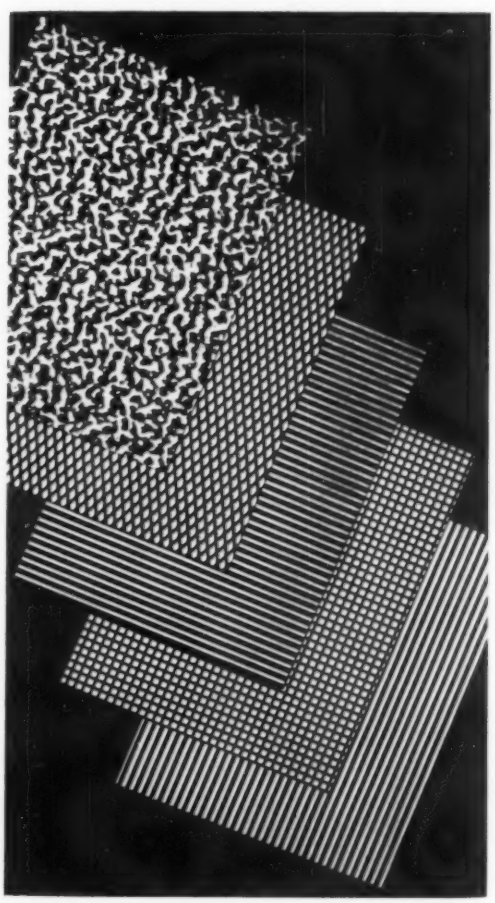
Kaiser is giving aluminum sheet a variety of colored patterns by applying a special rolling technique which combines two dissimilar aluminum alloys. A conventional anodizing procedure then brings forth the contrasting sunfast color patterns. "Inlay sheet" of this type, illustrated in Fig. 6, can be used for appliance and auto trim, for office equipment and for architectural design. The material is available as flat or coiled sheets in widths to 36 in. and thicknesses from 0.030 to 0.064 in.

Harvey Aluminum's "Anocote" process protects mill products from surface marks which develop during shipping and handling. Fabricators who anodize or etch report they obtain an exceptionally smooth, uniform finish that is free of defects. The new treatment does not alter the natural color of aluminum and it may be used as a final finish for various products.

Structural Applications Increase

Figure 7 presents Alcoa's decorative screen system, "Sol-dec", for concealing old building facades or creating sunshade or vision screens for new buildings. Although it has unlimited pattern possibilities, the system can be assembled with two basic extrusions and a clip. Standard and custom designs are precut and prefinished in any of 11 baked enamel colors.

Fig. 6 – Appearance of "Inlay Sheet" After Anodizing. The patterns are obtained by combining two dissimilar alloys during rolling



Wrought aluminum is moving into the guard-rail field. The standard rail, which has the same contour as a steel one, is made of Alclad 2024-T 3 and is available in three sheet thicknesses.

Harvey Aluminum reports that alloy 7001, developed for hot extruding, has recently been cold impact extruded into long tubes, producing exceptionally high tensile properties – around 90,000 psi. in the heat treated condition – with adequate ductility. Another Harvey alloy, 6066, (for use in shipping containers and storage units) has been modified to increase corrosion resistance, impact strength, and weld strength.

Aluminum alloys for cryogenic equipment, such as fuel storage containers for missiles and oxygen plants, offer some distinct advantages. Alloy 5154 and other 5000 series alloys maintain their ductility, strength, and resistance to shock loading at very low temperatures (−320° F.). In terms of initial cost and maintenance, aluminum offers substantial savings. Machining and joining characteristics also permit rapid fabrication.

New Alloys for Improved Properties

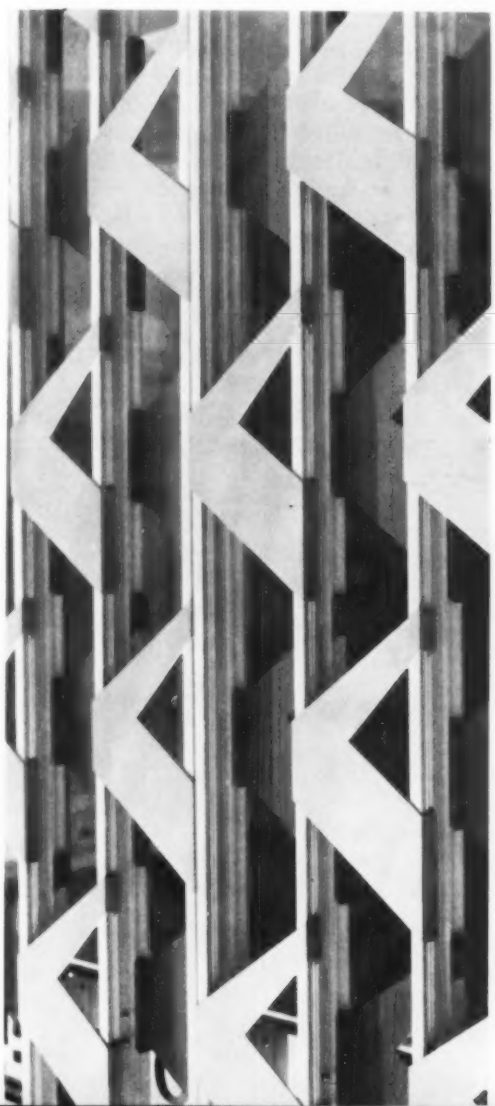
A heat treatable Alcoa alloy – X 2020, containing 1.1% Li and 4.5% Cu – has the room-temperature properties of the high-strength aluminum-zinc-magnesium alloys (7075, 7178, 7079) and the elevated-temperature (200 to 250° F.) strength of the aluminum-copper (2014 and 2024) types. The corrosion resistance and fatigue strength of X 2020 are comparable to present aircraft structural alloys. Low as-quenched (W) strength and a very slow room-temperature aging characteristic provide an ideal combination of properties for cold forming operations.

Alloy X 2219, containing 6.3% Cu and 0.3% Mn plus small amounts of vanadium and zirconium, was developed for use at high temperatures, but its weldability proved so interesting that many room-temperature applications are being considered. At 500° F., typical yield strength in the T 6 temper is 22,000 psi. The yield strength at room temperature varies from 36,000 to 48,000 psi., depending on thermal history and amount of cold work. Elongation is about 10% and the alloy is resistant to stress-corrosion cracking at these strength levels.

No evidence of notch sensitivity has been found in welded samples taken from the heat-affected zone, the parent metal, or the weld metal. (Alloy X 2319 filler metal is used for welding; it has the same composition as X 2219 except for a slightly higher titanium content.)

APM Impacts – Precision aluminum parts for high-temperature service are now being fabricated in the form of APM impact extrusions. The powder metallurgy technique – plus conventional hot extrusion – is employed to produce the slug from which the final shape is impact extruded. Close-tolerance parts can be fabricated by this process for severe service in the atomic energy, missile and aircraft fields. Figure 8 shows a ¼-in. diameter finned tube which can be impact extruded in lengths up to 14 ft. with wall thickness tolerances held to 0.003 in. The hollow cylinder is the APM slug from which the tube was extruded. APM slugs may be used "as-is", or they may be machined, die

Fig. 7 – "Sol-Dec" Screen Is Assembled From Two Basic Extrusions and a Clip. By varying the shape, color, and arrangement of the panelettes, an unlimited number of custom screen designs can be produced



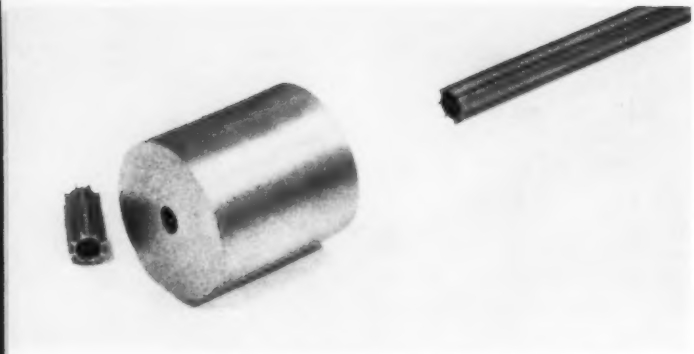


Fig. 8 – Finned Tube With Close Dimensional Tolerances Produced by Impact Extrusion. Powder metallurgy plus conventional hot extrusion produced the hollow slug

forged, rolled into sheet, or drawn into wire.

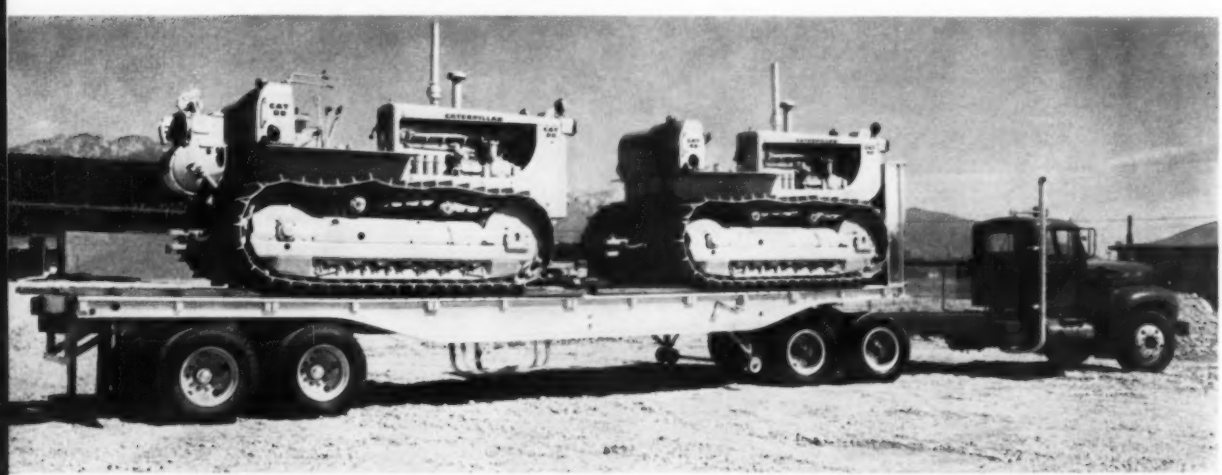
Ordnance Applications – Structural aluminum in combat vehicles is being employed extensively because the reduced weight allows them to be transported by air and dropped by parachute. Reduced fuel consumption and maintenance-free service add further benefits. Other ordnance uses include weapons and guided missiles together with ground-support equipment vehicles for transporting men and material on land or in the water, portable bridges, landing mats, cranes, shelters, and shipping containers. A new application is aluminum armor plate – it is lighter than steel and yet it gives equal ballistic protection.

Fig. 9 – A 40-Ft. Welded Aluminum Flatbed Trailer Weighing 7400 lb. The load consists of two tractors weighing 28 tons each

Progress in Welding

When mobile structures must be produced economically, aluminum extruded or rolled shapes are being fabricated by welding. For example, the National Science Foundation, at Green Bank, W. Va., is building a 140-ft. diameter radio-telescope by welding 5456 extruded tube into the form of a parabolic dish. A huge 600-ft. diameter dish incorporating similar construction features is now in the planning stage. Alloy 5456 plate and extruded shapes were also used in fabricating the aircraft elevator for the nuclear-powered carrier, Enterprise. A new welding design concept was utilized in fabricating the 40-ft. long flatbed trailer shown in Fig. 9. Most structural aluminum alloys attain their strength by heat treatment or strain hardening. Welding partially destroys these effects, causing the heat-affected zone and the weld to be weaker than the parent metal. This trailer design takes advantage of the full strength of the alloy and yet takes into account the reduction in strength at or near the weld.

The beam for the trailer is composed of top and bottom T-shaped 2014-T 6 extruded rails and a variable-width web section made of ¼-in. 2014-T 6 sheet. These pieces are joined by welding at or near the *neutral axis* to form an I-shaped load-carrying member with a variable-beam depth. This same design principle – placing the weld where the stresses are lower to utilize the full strength of the alloy – is applied when cylindrical pressure vessels or rocket cases are joined by circumferential welds rather than longitudinal welds.



A Report to
Technical Management

*Progress in Copper Alloys**

"Biofouling" is prevented by mercury added to copper . . . An age hardenable bronze finds use for cold headed bolts . . . Copper plus 0.15% zirconium has good stiffness and electrical conductivity . . . Lithium is a useful deoxidizer . . . Tubes of tin-lined copper and copper-lined stainless steel answer corrosion problems . . . Extrusions aid in rotogravure and lock manufacture . . . Shaped rod and bearings are produced by continuous casting . . . Ingenious method for fabricating printed circuits wins Copper and Brass Achievement Award. (A-general; Cu-b, 17-57)

COPPER – a metal which has been around in one form or another since the earliest times– continues to find new uses. New alloys have emerged from laboratories as have new ways for using the old, familiar coppers, brasses and bronzes.

For example, American Brass has recently announced a new precipitation hardening alloy termed "Leaded Nickel Copper-831". Composed of copper plus 1% lead, 1% nickel and 0.20% phosphorus, this free-machining bronze has, according to report, high tensile and yield strengths along with high electrical conductivity. The lead makes it free machining while the nickel and phosphorus combine to form nickel phosphide, the hardening agent. When hardened and cold worked, the tensile strength ranges from 80,000 to 85,000 psi., and the yield strength, from 70,000 to 75,000 psi. Conductivity is 55% I.A.C.S.

One of the most interesting new alloys is the corrosion resistant "Alloy 77". Developed by Bridgeport Brass Co., this is the first commercial copper alloy to employ mercury as an addition agent. According to its creators, the alloy is intended for use whenever trouble from algae growth can be expected. In the condenser and heat exchanger tubing, which is made from the alloy, the added mercury helps to limit corrosion and clogging by living organisms (the brass people call this "biofouling"). Experience has shown that the water-deposited scale is thin and easily removed, and that the tubes can be kept clean by a lower concentration of chlorine (or by less frequent or shorter chlorination periods). It is reported that the alloy resists dezincification and other forms of corrosive attack.

Bridgeport Brass also has another type of

*The editors gratefully acknowledge the assistance of the Copper and Brass Research Assoc. in preparing this report.

Fig. 1 – This Clad Tube-Sheet Is 36 In. in Diameter. When in use, this "sheet" contains holes in which tubes are inserted; it then serves as the end of a boiler or heat exchanger. (Courtesy Bridgeport Brass Co.)

bronze with a combination of valuable properties. Called Nironze 635, it is age hardenable and contains nickel and silicon; it combines good cold working properties with high tensile and yield strength. The alloy is useful for cold headed bolts and fasteners used in pole-line hardware, switching gears, wire connectors, neon signs, railway equipment, marine hardware and fittings.

Another material with much promise is zirconium-copper, a precipitation hardening copper alloy which contains about 0.15% zirconium. According to Westinghouse, whose researchers devised this alloy, its properties lie between those of pure copper and beryllium-copper. After hardening (by heating at 1650° F., water quenching, and aging at 750° F.), this alloy has an electrical conductivity which is 96% of that of tough pitch copper along with a modulus of elasticity of 18,700,000 psi. The alloy, which is produced by American Metal Climax, Inc. (AMCO), is useful where both stiffness and high electrical conductivity are desired.

Another alloy recently announced by AMCO is "Amsulf", a sulphur-containing copper which is said to have 4½ times the machinability rating of tough-pitch copper (raising it from 20 to 90), while retaining 96% of the electrical conductivity. The sulphur, according to the report, is present as thin particles of copper sulphides; these particles act as chip breakers to produce short chips which are easily disposed of. In addition, the alloy will not embrittle when it is heated in a reducing atmosphere, along with many of the other attributes of OFHC copper. Applications include nozzles, motor parts, switches and other electrical components, and soldering iron tips.

Along with mercury, beryllium and sulphur, lithium is now being added to copper. Actually, Wolverine Tube Co., which produces the alloy "Lideox", uses lithium (instead of the more conventional phosphorus) for a deoxidizing agent. According to the company's engineers, lithium has virtually no effect on conductivity, and it also offers much greater assurance against hydrogen embrittlement.

Beryllium-Copper Alloys

Casting alloys are also receiving much attention. For example, plastics fabricators have found two beryllium-copper alloys to be quite useful for components of molds. These alloys, designated 20 C and 275 C, contain 2.00 to 2.25% and 2.60 to 2.85% beryllium, respectively. (Both alloys also have 0.35 to 0.65% cobalt.)

During the past year, plastics engineers have adapted beryllium-copper for use in such injection mold components as nozzles, cylinders and spreaders. Because the alloy has high heat conductivity, operation temperatures remain more level throughout the die and the

Fig. 2 – Seal Strips, Made of Continuously Cast Nickel-Bronze, Are Inserted Adjacent to Rotor Blades to Restrict Leakage of Steam. Since they are individually cut from cast-to-shape bars, they offer considerable savings in machining costs. (Courtesy American Smelting and Refining Co.)

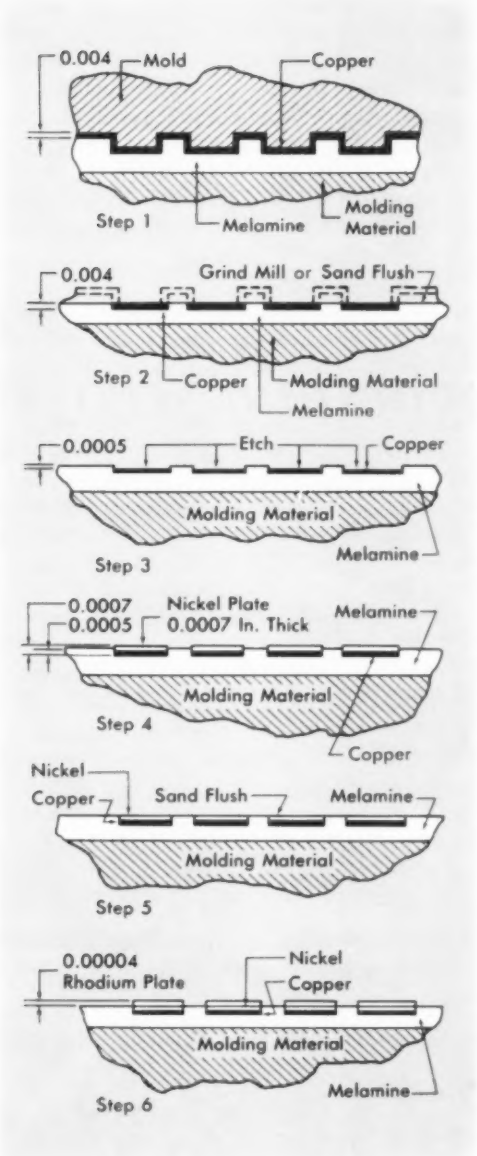


Fig. 3 – These Are Steps in the Production of the Molded Flush Circuit Which Won First Prize ($1000) in the Copper and Brass Achievement Award Contest. Its use simplifies the manufacture of printed circuitry

plastic compounds are less likely to burn. The alloys also resist corrosion by the acids which may be given off by some plastics when they are heated for molding. Cavities and components of beryllium-copper are also used advantageously in the blow-molding field.

Properties Are Being Investigated

A wide gap in the available information concerning the many casting alloys is now being gradually filled by a comprehensive series of investigations. Sponsored by the Brass and Bronze Ingot Institute, Battelle Memorial Institute is conducting a continuing program.

In a recent report (presented at the 63rd annual meeting of the A.S.T.M.), accurate measurements were made over a range of temperatures (from below zero up to 550° F.) for 16 mechanical and physical properties of the following alloys: 76 Cu, 2.5 Sn, 6.5 Pb, 15 Zn; 20% nickel-silver; 81 Cu, 4 Si, 15 Zn silicon brass; 65,000 psi. manganese bronze, and 110,000 psi. manganese bronze.

Data obtained are representative of the properties that can be expected when good melting, molding, and casting practice is used. Much of the data was previously not available to design engineers, architects, purchasing agents, and others who are concerned with specification in the manufacture of equipment or equipment components.

In previous work, Navy "M", 80-10-10, and 85-5-5-5 were investigated in the same manner. In time, similar information will be gathered for many other copper alloys.

Advances in Tubing

Developments are not only in new alloys; new uses for familiar materials are also appearing. For example, there are some innovations in tubing. For gas services, Phelps Dodge now markets a tin-lined copper tube which is intended to protect gas systems from sulphur. The internal coating of tin is bonded to the copper in such a way that it will not crack, peel or flake when the tube is bent or flared.

Another type of bonded tubing, marketed by Carpenter Steel Co., employs copper on stainless steel to produce a heat exchanger tube which will have good heat transfer characteristics along with resistance to corrosion by chlorides. Tubes such as these, which are produced by drawing copper or brass on the outside of welded tubes of stainless steel, have been used in two of Union Carbide's chemical plants in Texas. Reports are that they have solved a serious corrosion problem.

An unusual form of light-wall seamless tubing is also available. Called "Strubing" by its distributors, *(Continued on p. 154)*

A Report to
Technical Management

Progress in Magnesium Alloys

*By JAMES V. WINKLER**

Two new wrought alloys – ZE 10 A and ZK 21 A – require no stress-relief after welding . . . Precision extrusions minimize machining . . . New casting alloys – ZK 61 A, QE 22 A, EK 31 XA, HM 11 XA – offer improved properties at room and elevated temperatures . . . Better casting methods plus chemical milling give lighter parts . . . A new surface pretreatment allows porcelain enameling on magnesium. (A-general; Mg-b, 17-57)

THE DEVELOPMENT of magnesium sheet and extrusion alloys, ZE 10 A and ZK 21 A, which require no stress-relief after welding, has been a boon to the fabrication of large structures which cannot be stress-relieved on a practical basis. The most extensive use of these alloys has been in bulk shipping and handling containers, which were introduced a year ago and now are priced competitively with aluminum containers.

Large chemical storage hoppers (Fig. 1) are fabricated from ZE 10 A sheet and ZK 21 A extrusions. Good welding characteristics of the alloy, including weld efficiency, result in an economical structure. A missile manufacturer is experimenting with a portable hanger fabricated from ZK 21 A tube. Here, welded arch sections are the basic unit. Horizontal purlin members are bolted to five arch sections to form a module. Modules can be employed singly or in combination with others. Since no stress-relief is required, the ZK 21 A tube sections can be flown to any spot on the globe and assembled by welding.

Magnesium Sheet for Cold Bending

New applications for magnesium are expected to result from the development of a magnesium sheet for cold bending. Until recently, critical bends could not be made in this metal without using heated dies. With the new product, longitudinal bends can be made at room temperature, without cracking, over a mandrel radius of 2 t, and transverse bends, over a radius of 2.5 t.

Magnesium sheet is now being rolled in special thickness tolerances for aircraft and missile parts. The closer tolerances, one-half of the regular ones, are available in standard thicknesses in sheets up to 48 in. wide – in

*Manager, Technical Service and Development, Dow Metal Products Co., Midland, Mich.

AZ 31 B alloy as well as the magnesium-thorium alloys (HK 31 A and HM 21 A) which were developed specifically for supersonic aircraft and missiles. Since airframe engineers must design to minimum permissible thickness when computing area available for stress distribution, but to maximum permissible thickness when computing the part weight, closer tolerances on sheet result in further weight reductions.

The "Satellite Metal"

Based on the total weight of structural metal placed in orbit, magnesium is clearly the "satellite metal". The small satellites — Vanguard II and III and Pioneer V — contain magnesium sheet and plate components, but the principal contributor is the Discoverer (Agena A) series, which has gone into orbit seven times out of twelve firings with more than 600 lb. of magnesium-thorium sheet, extrusions, forgings and castings in each vehicle. The National Aeronautics and Space Administration employs a magnesium canister 28 in. in diameter to carry a 100-ft. diameter inflatable sphere into orbit for communications experiments.

The extensive use of magnesium sheet in supersonic missiles and aircraft has created a need for improved fasteners. Research has pointed to high-purity 5056 aluminum alloy as an excellent fastener for magnesium in such applications at both elevated and room temperature, and fasteners are now available as rivet alloy C 911.

Drawing Magnesium Parts

Current experimental work is defining the limits of magnesium's drawability on faster-acting mechanical presses. Draws up to 40% have been made with cylindrical parts, such as the one shown in Fig. 2, at a speed of 35 strokes per min. (50 ft. per min. ram velocity) at 400° F. — a temperature sufficiently low that a graphite lubricant is unnecessary.

Precision magnesium extrusions are extrusions furnished from the mill with tolerances as good as obtained in machining. Tolerances on critical cross-sectional dimensions are as low as ±0.001 in. The extrusions are found as components of electronic equipment, furniture, missiles, compressors, printing equipment, aircraft, and business machines.

Sand-Casting Alloys

New alloys are extending magnesium's serviceability in military applications. ZK 61 A-T 6, containing zirconium, is the highest-strength magnesium alloy at room temperature. QE 22 A, an alloy of magnesium with silver and didymium (a combination of rare earths) invented in Great Britain and available in this country, exhibits better properties in the middle-temperature range. It has the highest yield strength

Fig. 1 — Chemical Storage Hoppers Fabricated From Magnesium Sheet Alloy ZE 10 A and Extrusion Alloy ZK 21 A. These alloys require no stress-relief after welding

Fig. 2 – The Part Shown Demonstrates the Drawability of Magnesium on Fast Mechanical Presses. It was made from a blank 0.032 in. thick and 9¼ in. in diameter. A reduction in area of 40% in one draw produced a part 6 in. in diameter by 2⅛ in. deep with a ¼ in. flange

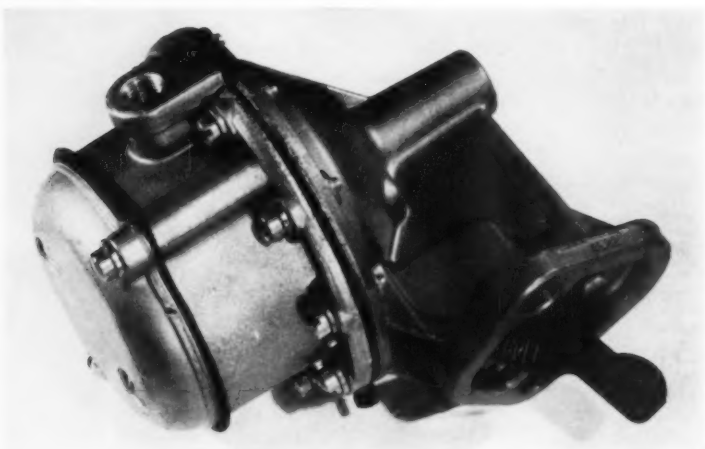


Fig. 3 – Magnesium Die-Cast Parts Produced by Automatic Metering Process. Pulsator cover, diaphragm support and air body of an automotive fuel pump are shown

of any magnesium casting alloy up to 560° F. EK 31 XA, a magnesium-didymium-zirconium alloy, offers an excellent combination of room and elevated-temperature properties. HM 11 XA is a die-casting alloy of the magnesium-thorium family; its introduction means that magnesium-thorium alloys are now available in all standard forms. Thorium additions to magnesium extend its range to 800° F.

Advances in sand casting have brought improved tolerances. For example, for a magnesium waveguide section now being produced in volume the tolerance on the sides of the waveguide passageways is ±0.005 in., the tolerance on the total location relationships of the passageways is ±0.008 in., and the surface finish is rms. 63.

Chemical milling of magnesium, initially employed on wrought products, can now be applied to sand castings. Wall thickness as low as 0.070 in., as well as improved surface smoothness, is obtained.

Die Castings

The automatic metering process for magnesium die casting continues to attract considerable interest because of increased use on a production basis and its promise as the means to a truly massive use of the metal. The production economies of the process are favorable. Components of the fuel pump shown in Fig. 3 were produced in this manner. In addition, a low-pressure permanent-mold process is under development.

Welding and Brazing

An important development is the refinement of consumable electrode, inert-gas (MIG) welding, which is three to five times faster than tungsten-arc (TIG) *(Continued on p. 158)*

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Circle 1533 on Page 48-B

CORRESPONDENCE

Can Refractory Metals Be Protected by Glass?

BERKELEY HEIGHTS, N.J.

Here is an idea that was sparked by *Metal Progress* articles concerning difficulties in fabricating and handling refractory and brittle metals and alloys. Briefly, it is known that metals can be rolled, drawn or formed under glass. If we select a glass which softens in the plastic or molten range of an alloy or metal, both glass and metal can be rolled or formed together. The glass serves as an envelope protecting against atmospheric attack, and as a support as well. This envelope can be evacuated or can contain an inert or reducing atmosphere.

Since glasses can be formulated to soften at nearly any temperature in a range from 900 to 3000° F., most metals would be susceptible to this treatment. Ceramics other than glass might be useful in the higher ranges. Heat can be applied externally or produced internally by induction.

Lacking technical knowledge and equipment, I have been able to test this hypothesis only in a crude manner. I experimented with a brazing alloy (80% Cu, 15% Ag, 5% P). At room temperature this alloy is fairly brittle and is difficult to roll. However, when placed in a glass tube (soda lime glass, softening point about 1200° F.) and heated to the melting point of the metal, I was able to flatten, roll, twist, stretch out in fine filaments and otherwise manipulate both glass and metal in concert. When cooled, the glass was easily broken away leaving the metal in final form.

This simple experiment has encouraged me to believe that any metal or alloy can be handled in similar fashion, protected and supported by a glass or ceramic covering. Do any readers of *Metal Progress* have further suggestions?

FRANK M. GAULT

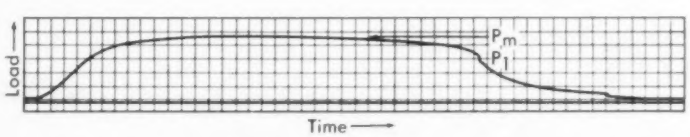
A Bend Test for Toughness

INDIANAPOLIS, IND.

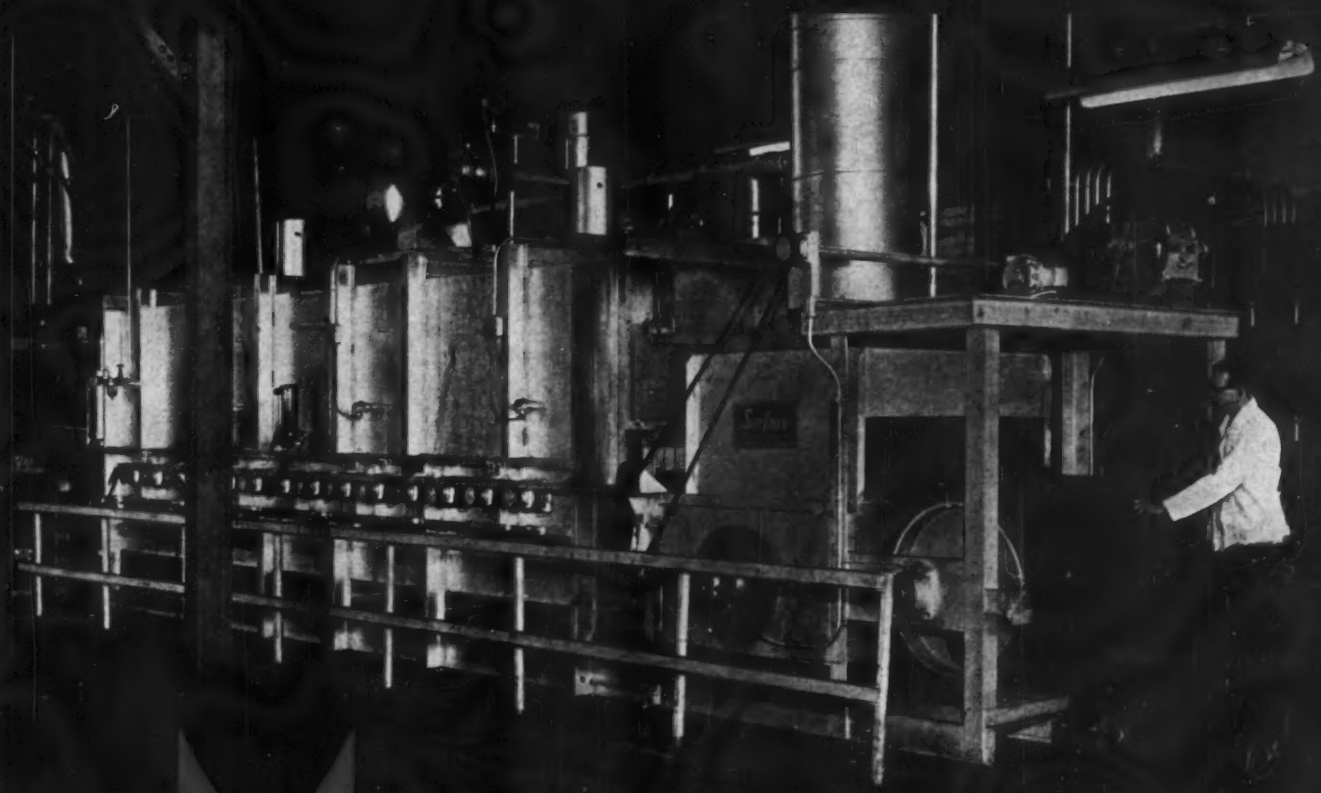
It was unfortunate that the editorial copy sent to the authors of the paper on the above subject in the August issue did not include the illustrations. The chart in Fig. 2 prepared by your draftsman made a rather serious error in the proper interpretation of the "instrumented bend test". I refer specifically to the fact that the curve does not show a sharp break at P_1 load. That is, the curve reflects too gradual a drop from the maximum load where the first crack occurs to the breaking load where the curve exhibits a tremendous increase in slope. [A redrawn and corrected curve appears herewith – EDITORS.]

Actually the curve as printed in August *Metal Progress* would reflect a test on soft steel whose mechanical properties lie outside the bounds of interest in connection with conducting a crack propagation test. This is stated in the second paragraph on p. 92. Picking up the details of such a sharp break in the curve at load P_1 is the only reason for an oscillographic record, since this sharp break is truly the crux of an accurate test.

D. K. HANINK
Chief Metallurgist, Allison Div.
General Motors Corp.



Typical Record From Bend Test. Values for bend parameter are calculated from P_1 (the stress when cracks first appear) and P_m (the maximum stress), and it is a measure of the resistance to crack propagation



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(3) reduce handling operations, consequently reassign personnel to more productive jobs.

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Mr. Leonard Ewalt, Chief Metallurgist of Ross Gear, reports: "The furnace will heat through a 2-inch section in approximately 40 minutes—just about as fast as the metal can take it when heated by convection . . . I would say that with this method of distributing heat in the zones and the rapid heating rate, this Power Convection furnace* is a couple of years ahead of its time.

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Circle 1534 on Page 48-B

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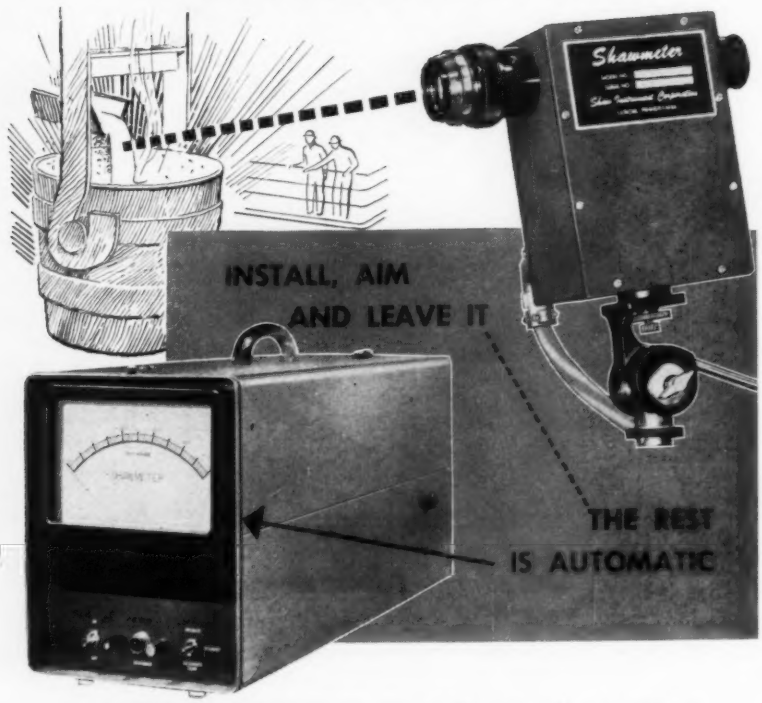

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Circle 1535 on Page 48-B

Vapor-Shielded Arc . . .

(Continued from p. 99)

the fixture mandrel. A clamping mechanism eliminates the necessity for pretacking. Inclining the mandrel at an angle of 10° from the horizontal and the welding head at 35° from a vertical position aids in achieving maximum welding speed. The ground clamp is air actuated and fastens to the underside of the shell at the finish end.

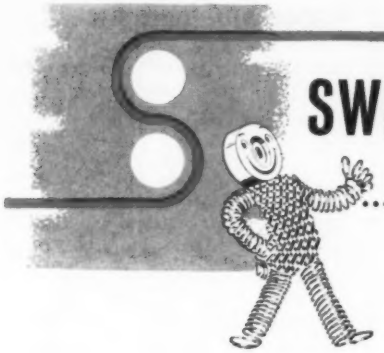
Welding progresses toward the ground, just the opposite of submerged-arc procedures, at 155 in. per min. with a setting of 950 amp. and 24 v. A constant potential generator supplies the power. Girth welds on the tank are also made at 155 in. per min. The welding head is positioned at a 35° angle from the horizontal and about 3 in. from the top of the tank opposite the direction of rotation.

An important advantage of the new process in this application is its ability to produce a more uniform weld contour on the inner side of the longitudinal seam. Elimination of adhering slag or slag pockets is desirable in tank manufacturing where galvanizing follows the welding operation. Also, the process has reduced the number of tanks which leak to less than 1% – a good record in this application. Typical ampere settings on tanks that vary in thickness from 10 to 16 gage range from 950 to 600 amp. Welding speeds of from 115 to 200 in. per min. have almost doubled the output of the line.

The ability of the process to tolerate rust without producing porosity is pointed up in the fabrication of lightweight beams by United Steel Fabricators, Wooster, Ohio. A fixture supports the beam in a 45° position while the flat-positioned weld is being made at 90 in. per min. This high speed minimizes distortion.

High-Volume Auto Parts Made

The new process is also being used at Electric Auto-Lite Co., Toledo, Ohio, to produce a continuous weld 888 ft. long at a rate of 144 in. per min. Welding is done at 750 amp. and 25 v. with a ⅛-in. electrode. In this application, the work is being fed under the stationary welding head as shown in Fig. 1 (p. 97). This welding station is in a produc-



SWIFT'S ANTI-FRICTION ACTIVITIES

FREDDIE F. REPORTS ON:

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S-73A

Circle 1536 on Page 48-B

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2. Iridite provides a highly protective non-porous paint base.
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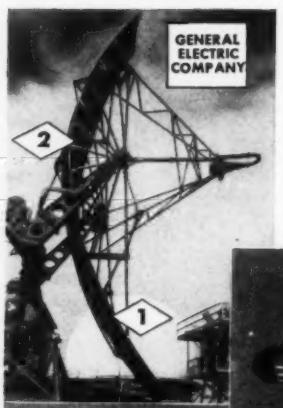

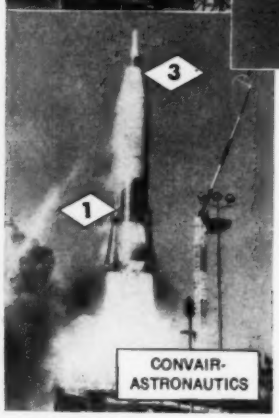

And, Iridite gives you these additional advantages:

ON ALUMINUM—needs only normal precleaning. Film withstands cold forming or bending. Easily heliarc welded. Unusually low electrical resistance. Clear, yellow or dye-colored finishes.

ON MAGNESIUM—short immersion, room temperature solution, no electrical equipment. Corrosion protection relatively unaffected by high drying temperatures. Applicable to all alloys. Low electrical resistance. Color ranges from light gray to dark brown.

IRIDITE—a specialized line of chromate conversion coatings for non-ferrous metals. Easily applied at room temperatures with short immersion, manually or with automatic equipment. Forms a thin film which becomes an integral part of the metal. Cannot chip, flake or peel; special equipment, exhaust systems or highly trained personnel not required.

For complete information on Iridite, contact your Allied Field Engineer. He's listed under "Plating Supplies" in the yellow pages. Or, write for FREE TECHNICAL DATA FILES.

Iridite is approved under government and industrial specifications.

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Circle 1537 on Page 48-B

Vapor-Shielded Arc . . .

tion line which is tooled to form and weld ⅛-in. thick strip steel and then cut off finished cylinders in 6 and 7-in. lengths.

Cu Alloys . . .

(*Continued from p. 145*)

Wolverine Tube Co., it is shipped in the form of ribbon and inflated at the point of use. Potentially, this type of tubing is usable in construction, electric power distribution, rockets and missiles, and general manufacturing.

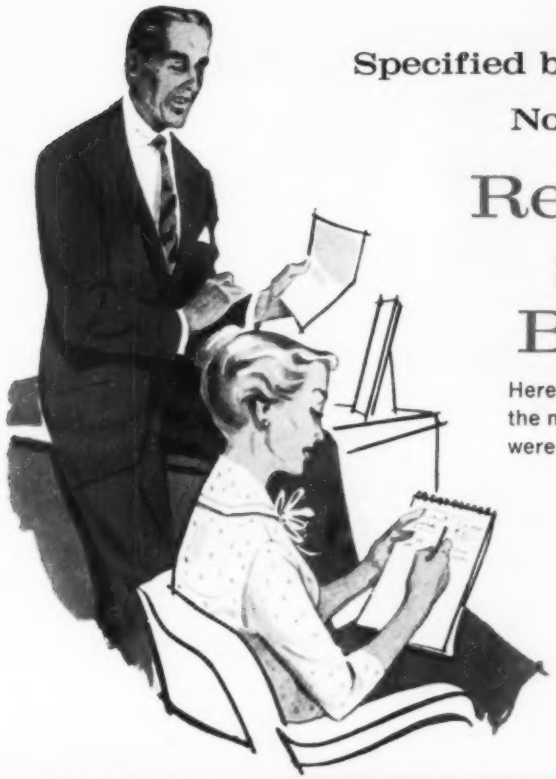
In line with these advances in tubing technology, Bridgeport Brass has recently announced that it has installed equipment to produce clad tube-sheet up to 42 in. in diameter. ("Tube-sheet", as far as the boiler industry is concerned, is the plate at the end of the boiler in which the tubes are inserted.) As made by Bridgeport Brass, these sheets generally consist of steel cores with copper clad to both surfaces. Other metals can also be clad to the steel sheet; the metal used depends on the type of corrosion resistance which is needed.

Extrusions Offer Savings

In the extrusion field, two applications have recently appeared. Anodes of phosphorized copper (used for plating rotogravure cylinders) are now being extruded to precisely curved shapes. This design helps to produce a smoother copper deposit on the cylinder because the distance between the cylinder and the anode is more uniform. In many instances, finishing operations have been reduced by as much as 50% by this technique.

Another cost-reducing application for extrusions has appeared in lock manufacture. Working closely with Anaconda specialists from early design stages, engineers of Welch, Inc., devised a lock mechanism around parts which could be cut from long lengths of extruded brass rod. Subsequent machining and scrap losses were cut considerably, and the smooth surfaces provided by extrusion reduced many finishing operations as well.

The continuous casting process is becoming a useful method for pro-



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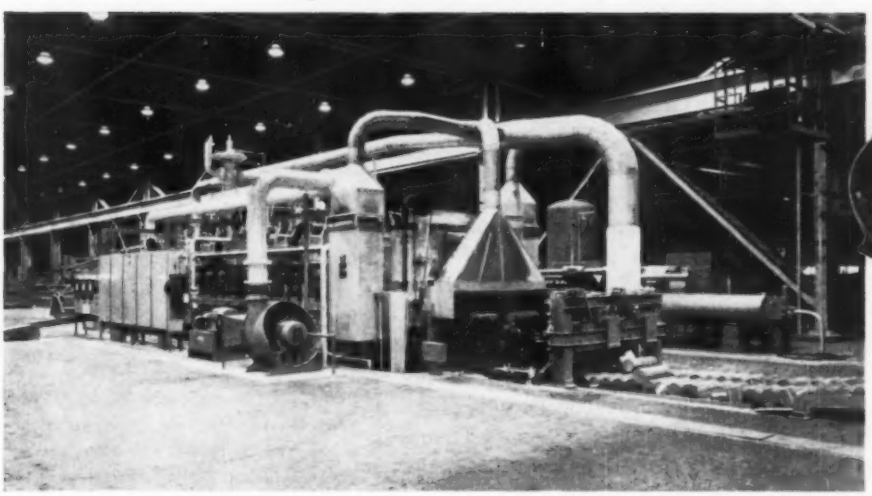
Here, as on countless other applications throughout the metalworking industry, Spencer blowers were selected because of their

DEPENDABILITY— Reduced "down time" and minimum maintenance because of simple, rugged construction. Lightweight impellers the only moving parts.

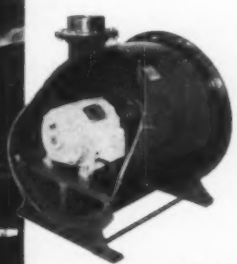
DELIVERY OF CLEAN AIR— All bearings are outside of casing. Hence, air cannot become contaminated with oil.

COMPACTNESS— Solidly constructed, no unnecessary bulk.

EASY MOUNTING— No bolting down or grouting required. No special foundations required.



Gas fired, two row, chain strand conveyor furnace . . . product of The Electric Furnace Co., Salem, Ohio.



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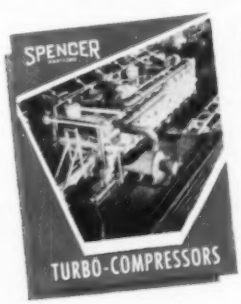

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Up to 20,000 C.F.M.
4 oz. to 10 lbs. pressure

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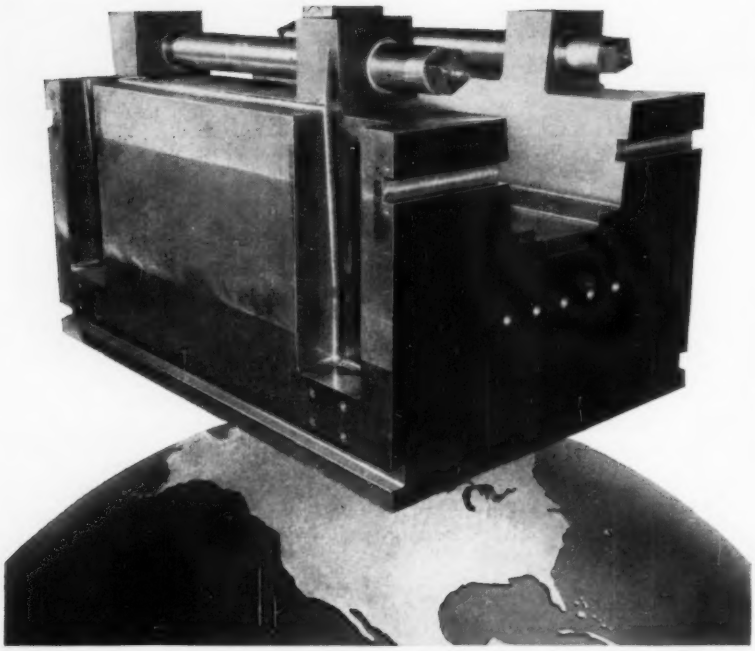
HARTFORD 6, CONNECTICUT

Circle 1538 on Page 48-B



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TO MAKE THIS 36,000 POUND DIE HOLDER

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In this rarefied atmosphere, unwanted hydrogen, oxygen, non-metallic inclusions, and other impurities are literally boiled out of the molten steel, producing cleaner, tougher, stronger, more ductile, flaw-free products.

This 36,000 pound, 40" x 44" x 64" die holder is used in a heavy duty press. It was made of Finkl FX analysis, Temper 4, and finished machined in our shops.

All Finkl die blocks and hot work die steels are made from vacuum degassed electric furnace material produced in our own melt shop. Because of the clean, greatly improved qualities, you get more forging production, less downtime due to breakage, and savings in fewer tool regrinds.

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Circle 1539 on Page 48-B

Cu Alloys . . .

ducing shaped parts with small dimensions. As an example, refer to Fig. 2, p. 144, and observe the seal strips being inserted adjacent to the blades in a large turbine rotor. Made of leaded nickel-bronze, these strips restrict steam leakage past the rotor blades to increase turbine efficiency. The strip, after being purchased in cast-to-shape bar stock, is milled and cut into segments of the proper length for installation. Previously, the material used for sealing was cast with virtually no shaping, and the large amount of milling needed resulted in substantial waste.

Continuously cast bushings of bronze are also being used in large diesel engines. They have replaced sand-cast bushings which, according to reports, had been collapsing in test runs and field use. Investigation proved that the sand castings had been porous, and had therefore absorbed considerable quantities of oil. In contrast, the continuously cast bushings were completely free from porosity, and had high density along with a uniform grain structure. Substitution of continuous castings for the sand-cast bushings, according to engineers, has resulted in two years of complete freedom from bushing failure. Furthermore, there has not been one instance of bearing seizure.

Innovations in Design

No article about new developments in copper would be complete without some discussion of the annual contest sponsored by the Copper and Brass Research Assoc. This year, the Copper and Brass Achievement Award, created by the Association to honor the year's outstanding development in copper or its alloys, was won by an ingenious method for manufacturing printed circuits. (Winners were Bell and Stosuy, formerly with International Business Machines Corp.) Flush with the insulating backing and mechanically bonded to it, this circuit is exceptionally resistant to mechanical, chemical, electrical and thermal effects. As Fig. 3 on p. 145 shows, few steps are needed in its fabrication. The process makes the manufacture of printed circuitry much more flexible; production panels of printed wiring had previously been

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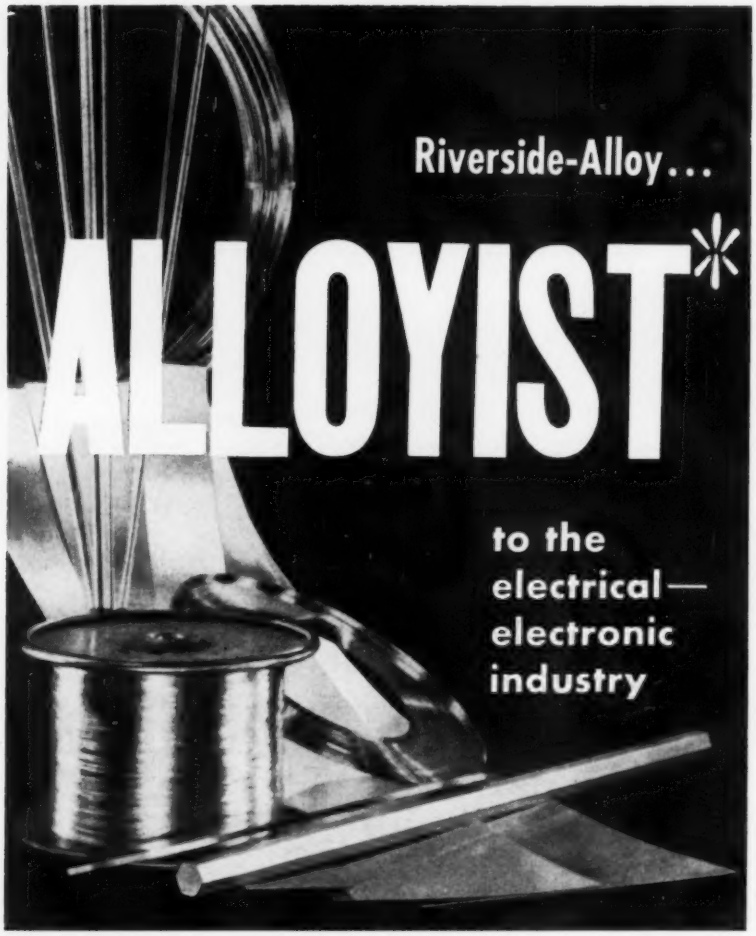
Circle 1540 on Page 48-B



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Circle 1541 on Page 48-B

Cu Alloys . . .

limited to flat patterns on laminated surfaces.

This process permits the use of any moldable plastic for the support of flush electrical conductors. Moreover, any desired shape can be molded. Also eliminated is the use of standard adhesives for bonding because the copper conductor is mechanically bonded to the laminate. Thus, it is possible to fabricate and machine these molded components at higher temperatures than can be done when adhesives are used.

Other entries which won awards included a time-delay fuse (employing a solid copper heat sink and links of brass and copper), and a heat dissipator for meters. The latter item, which uses solid copper ends and force-fixed Manganin rods, shunts excess heat so efficiently that it can be operated at double its rated capacity to give full deflection on 100-millivolt ammeters.

Mg Alloys . . .

(Continued from p. 148)

welding. It is being used in the fabrication of materials handling equipment and military hardware ranging from tanks to missile airframes. Flux-dip brazing, which has recently become practicable for magnesium, is being used for waveguides.

Tooling Metal

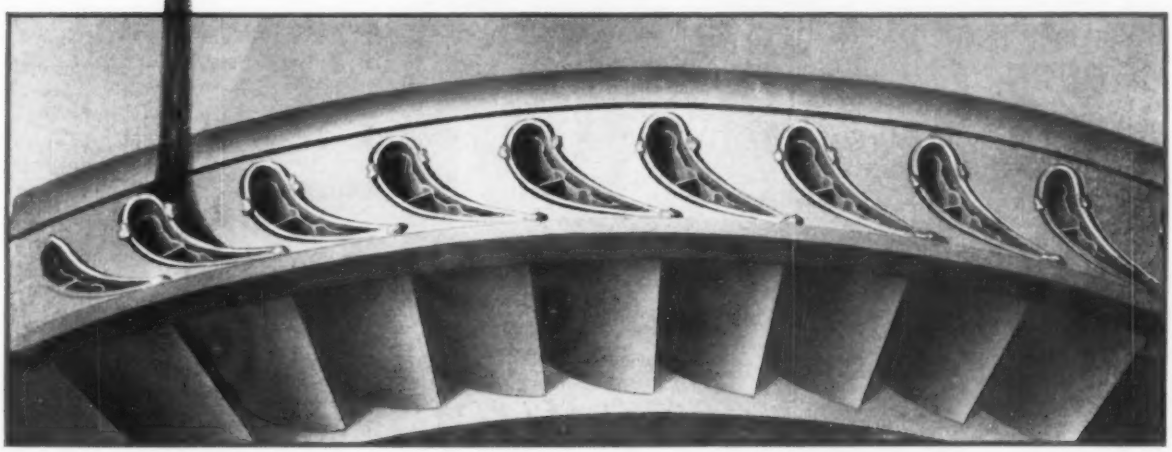
A large aircraft and missile manufacturer now uses magnesium tooling plate and the tube almost exclusively for vibration-test fixtures. A variety of other uses have been developed by shops large and small, exploiting the material's light weight, as-delivered flatness, machinability, weldability, dimensional stability and damping capacity. Meeting the flatness requirements for phototemplet and layout work, a new magnesium tooling material is offered with a primer coat that accepts diazo-type, light-sensitive emulsions.

Simpler Finishing Procedures

The Dow 20 chemical treatment, a modification of the standard Dow 1 chrome pickle (modifying constituents are magnesium sulphate and sodium acid fluoride), provides a uniform coating for die castings and for sand and permanent-mold

Metallurgical Memo from General Electric

G-E Vacuum-Melted Alloys Now Conquer Wide-Gap Brazing Barriers



Wide-gap brazing alloy is applied to turbine nozzle assembly. Vanes are tack-welded in position prior to brazing.

New G-E Wide-Gap Brazing Alloys offer:

- New brazing techniques
- Bridging of joint clearance up to .060 in.
- Faster, more simplified job fabrication
- Extreme cleanliness provided by induction vacuum melting
- Improved erosion characteristics
- Solution to many problems of distortion and stress relieving associated with fabrication by welding
- Lower manufacturing cost

Looking for new methods of fabricating high-temperature metals? Nothing can equal G-E vacuum-melted brazing alloy powders for critical applications. All provide the ultimate in exacting chemical control and extreme cleanliness which air-melted alloys cannot match.

Now this latest G-E brazing "breakthrough" of wide-gap alloys extends the use of brazing to a new, wider scope of joining applications.

Get all the facts about G-E vacuum-melted brazing alloys as a short-cut to lower cost manufacturing methods. Write: *Metallurgical Products Department of General Electric Company, 11113 E. 8 Mile Avenue, Detroit 32, Michigan.*

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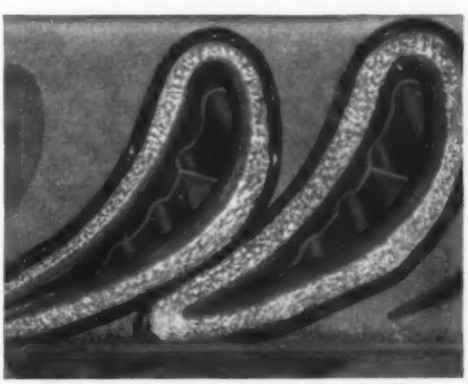


Insert shows vanes completely brazed in spite of gaps. Stains around perimeter of brazes are from stopoffs.

CARBOLOY® CEMENTED CARBIDES • MAN-MADE DIAMONDS • MAGNETIC MATERIALS • THERMISTORS • THYRITE® • VACUUM-MELTED ALLOYS

Circle 1542 on Page 48-B

HOW TO BEAT THE HEAT

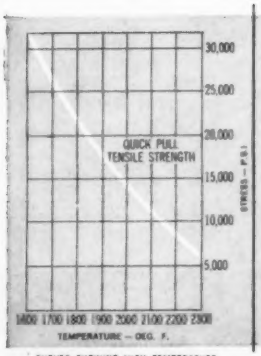
for strong high alloy requirements in the 1,800° to 2,300° F range!

DURALOY HOM*

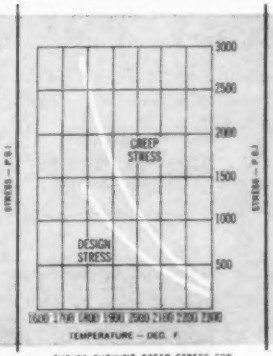
*Covered by U.S. Patents

casting alloy

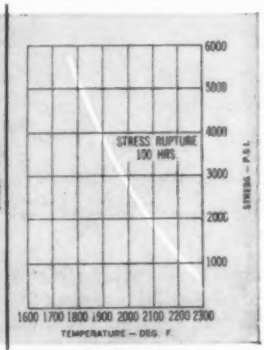
Duraloy "HOM" is a special high nickel alloy developed to produce castings that meet high temperature requirements, especially when castings are subject to oxidizing atmospheres.



CURVES SHOWING HIGH TEMPERATURE SHORT-TIME TENSILE STRENGTH OF DURALOY-HOM



CURVES SHOWING CREEP STRESS FOR CREEP RATE OF 1% IN 10,000 HOURS AND RECOMMENDED DESIGN STRESS FOR DURALOY-HOM



CURVE SHOWING STRESS TO RUPTURE AT 100 HOURS FOR DURALOY-HOM

Castings of DURALOY "HOM" are now being produced by our three methods: static, centrifugal and shell molded. Write today for additional information on this versatile new alloy.

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Circle 1543 on Page 48-B

Mg Alloys . . .

castings of high aluminum content. Dow 21 is a ferric nitrate pickle treatment that provides a bright finish for "shelf life" and for short periods of service. Applicable to all forms of magnesium, it can replace both the Dow 15 treatment for wrought alloys and the Dow 16 treatment for castings, thus simplifying commercial finishing procedures.

Lead oxide and lithium phosphate porcelain enamel finishes can now be applied to magnesium, if given a new surface pretreatment which promotes adhesion. These enamels offer durability at room and elevated temperatures, attractive appearance, and excellent corrosion resistance.

Plating on Magnesium*

Zinc can now be electroplated directly on magnesium. The process, developed by Mag-Al Plating Systems, Inc., of Indianapolis, requires no zinc immersion pretreatment. It permits the direct plating of thick zinc films which may be followed by conventional plating of copper and other metals.

The use of electroplated magnesium housings for electronic equipment is increasing. Tin coatings are plated, then reflowed, to provide RF contact and solderability on many housings. For some electronic and outer space applications, gold plating is being used.

*Additional information from J. S. Kirkpatrick, vice-president, research and development, Brooks and Perkins, Inc., Detroit.

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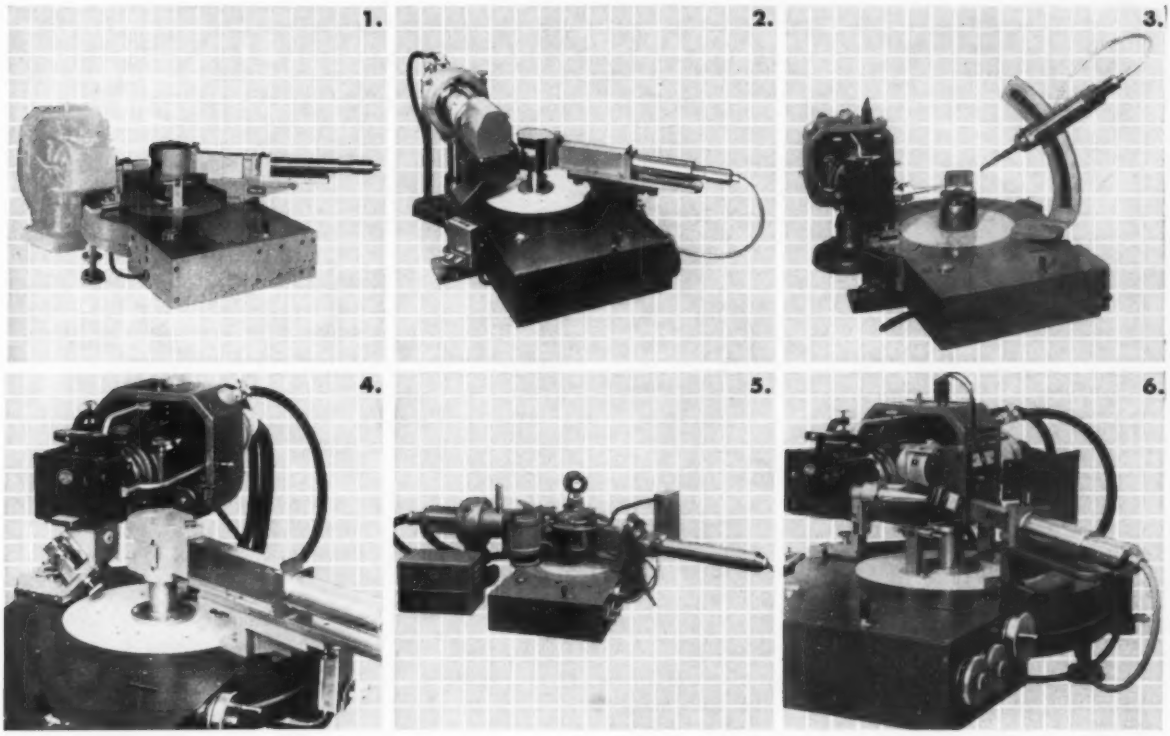

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RCA's horizontal goniometer performs 6 functions

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Crystalloflex IV and Electronic Circuit Panel with Vacuum Spectrometer and Diffractometer mounted on the generator.

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Circle 1544 on Page 48-B

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PERSONAL MENTION

Frank G. Foote

Russell Franks

FRANK G. FOOTE, director of the metallurgy division of Argonne National Laboratory, Argonne, Ill., took part in ceremonies marking the dedication of new laboratories for research in nuclear energy, operated by the Argentine Atomic Energy Commission, in Buenos Aires at the end of July. During his stay in South America he also visited the laboratories of the Bariloche Atomic Center in San Carlos de Bariloche in Argentina and the Brazilian Atomic Energy Commission in Sao Paulo, Brazil.

Dr. Foote has been associated with the United States atomic energy program since 1942 when he became principal metallurgist at the metallurgical laboratory of the University of Chicago, the forerunner of Argonne. During the intervening years, he spent two years at Columbia University as an associate professor of metallurgy, then returned to direct metallurgical activities at Argonne.

His division conducts applied and fundamental research in properties of such nuclear-age metals as uranium and plutonium, ceramics, ceramic-metal combinations, and the metals used to clad nuclear fuel. A $17,000,000 Fuels Technology Center nearing completion at Argonne will house the metallurgy division.

RUSSELL FRANKS can be credited with many of the major metallurgical developments in stainless and alloy steels evolved during his more than 40 years with Union Carbide Corp. Now retired from his job as manager of Union Carbide Metals Co.'s marketing research division, he still continues to serve the company in a consulting capacity.

His career with Union Carbide dates back to 1919, following his service in World War I. He soon decided to complete his education and after receiving his B.S. degree in chemical engineering in 1921 from Virginia Polytechnic Institute returned to the company's research laboratories, serving in various positions until 1943 when he was named chief metallurgist. He was transferred to the Electro Metallurgical Co., the predecessor of Union Carbide Metals, three years later as chief metallurgist of the technical service and development group. He was made manager of development in 1950 and manager of the marketing research division when it was organized in 1956.

Among his significant contributions to metallurgy are the use of columbium as a stabilizer to inhibit intergranular corrosion in austenitic stainless steels and the development of the Hastelloy corrosion resistant alloys. He holds more than 50 U.S. patents on stainless and alloy steels.

On his roster of technical affiliations are A.S.M., A.S.T.M., A.I.M.E., S.A.E. and the British Iron and Steel Institute. He was awarded the A.S.M. Henry Marion Howe Award in 1950.

C. R. Funk – from manager, metallurgy and engineering, Alco Products, Inc., Latrobe, Pa., to chief metallurgist, eastern division, Colorado Fuel & Iron Corp. with headquarters in Claymont, Del.

John A. Kalasky – from central foundry division, General Motors Corp., Saginaw, Mich., to senior metallurgist, Hamilton Watch Co., Lancaster, Pa.

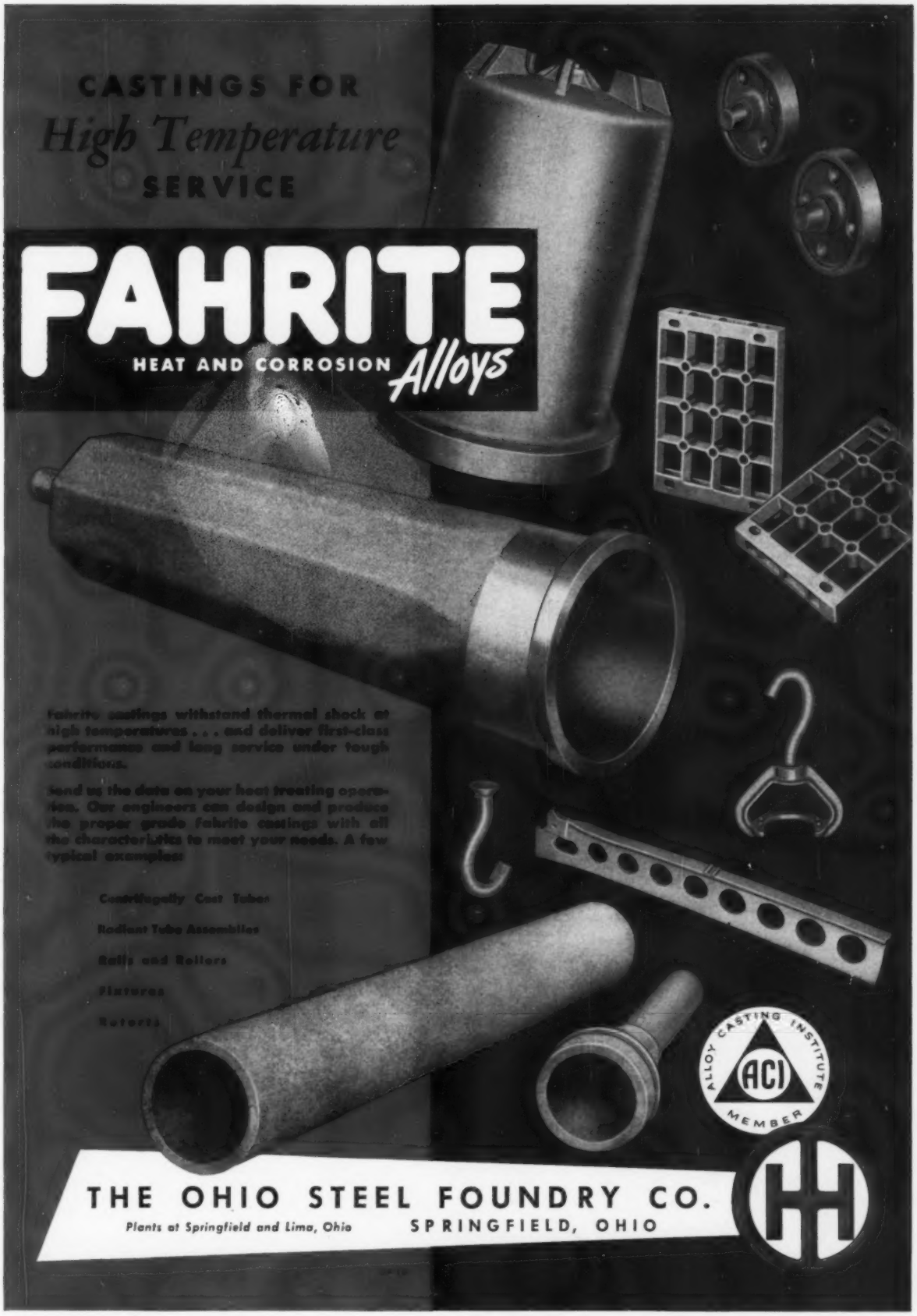
Frederick Card – from Westinghouse Electric Corp. to basic science laboratory of Stromberg-Carlson, division of General Dynamics, as senior physicist working on semiconductor material studies.

Carol Dean Lundin – released from active duty with the U. S. Navy, now working toward his master's degree in metallurgical engineering at Rensselaer Polytechnic Institute while working full-time for the Institute.

Roger A. Paquin – from research assistant in the metallurgy department of Stevens Institute of Technology (where he received his master's degree in June) to assistant engineer at Air Reduction Co.'s research Laboratories located in Murray Hill, N. J.

A. David Single – from materials specifications engineer at Underwood Corp., Hartford, Conn., to metallurgist, Pratt & Whitney Aircraft, Canel Div., Middletown, Conn.

J. K. Munhall – from sales engineer for Wheelco Instrument Div. to manager of a new manufacturer's agency, Penn-General Sales Co.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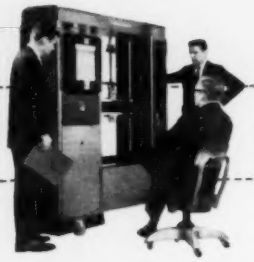

a new dimension in precision metals testing

Twinning in Face-centered Cubic Metal

Recent studies of the deformation characteristics of copper single crystals at 4.2°K and 77.3°K were made on the Instron Universal Tester equipped for low temperature testing.

Special x-ray techniques were used to examine the tested samples . . . one of the results: *mechanical twinning in face-centered cubic metal.*

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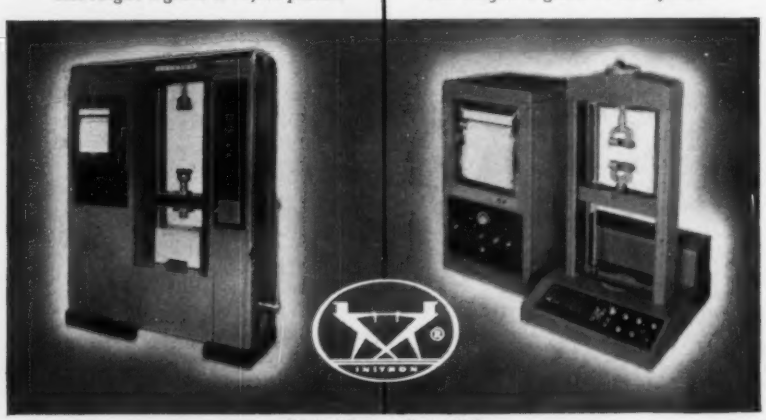
TABLE MODEL INSTRON — *full scale load ranges: 2 grams to 200 pounds.*



Circle 1546 on Page 48-B

Personals . . .

A. R. Matheson – from manager, reprocessing, Sylvania-Corning Nuclear Co., Inc., to sales manager, nuclear fuels department, Spencer Chemical Co., Kansas City, Mo.

V. L. McEnally, Jr. – from staff metallurgist, production engineering, missile division, to production engineering, corporate staff general office at the John R plant, Chrysler Corp., Detroit.

Byung J. Kim – now metallurgist, Michael-Rand Plating Co., Van Nuys, Calif.

Ruel F. Williams – from finishing department process engineer, extrusion plant of Reynolds Metals Co., Phoenix, Ariz., to plant metallurgist and quality control supervisor in Michael Flynn Mfg. Co.'s new extrusion plant, City of Industry, Calif.

Fred O. Von Plinsky – now supervisor, metallurgy section of the expended core facility, Westinghouse Atomic Power Laboratory.

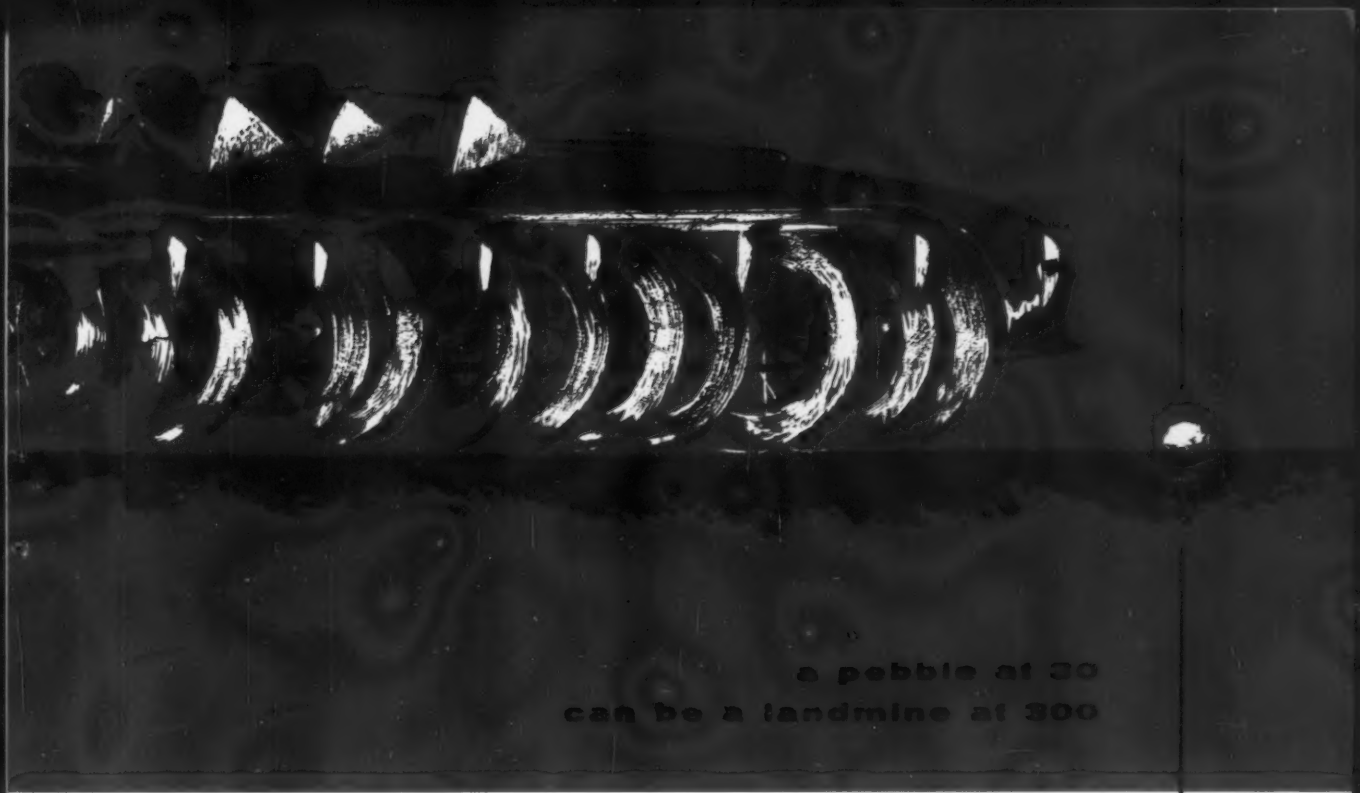
Arthur S. Coffinberry – for many years head of the metallurgical work on plutonium at Los Alamos Scientific Laboratory (where, of recent years, much attention has been centered on liquid fuels for nuclear reactors) is now in Mol, Belgium, on a year's leave of absence, at the Centre d'Etude pour les Applications de l'Energie Nucleaire, where his interests will be largely on the development of solid fuel elements.

Edward B. Gempler – from the General Electric Co. to senior metallurgist in the central research and development division of Carrier Corp., Syracuse, N. Y.

Stanford O. Smith – now general manager of Mercer Alloys Corp., Greenville, Pa.

Joseph D. Duke – transferred by U. S. Steel Corp., from T.C.I. Div. to the Research Center in Monroeville, Pa., for one year's work in fundamental research, working on process metallurgy. He will return to T.C.I. Div. next May.

Thomas E. Murphy – from sales representative, Long Island territory, New York Warehouse, to assistant manager of toolsteel sales, Carpenter Steel Co., Reading, Pa.



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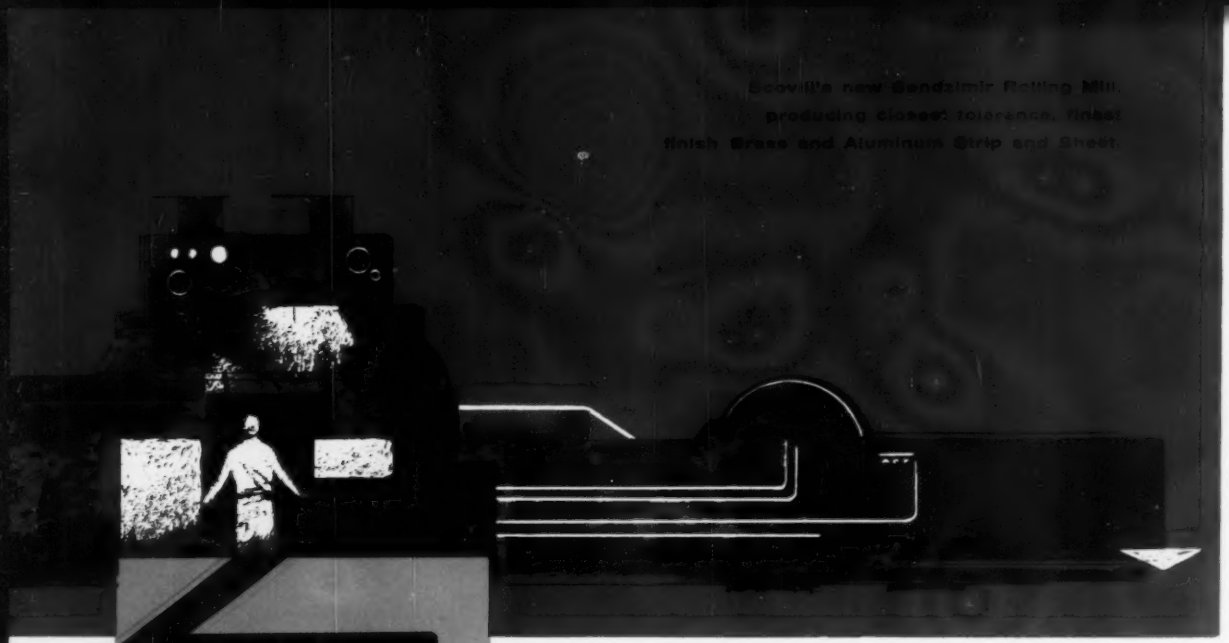

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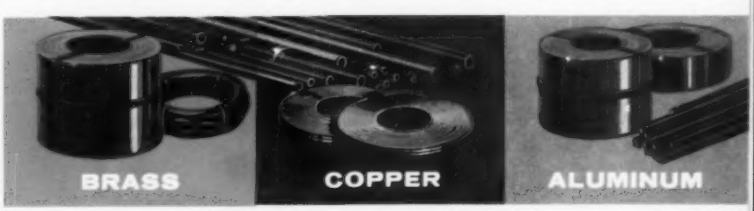

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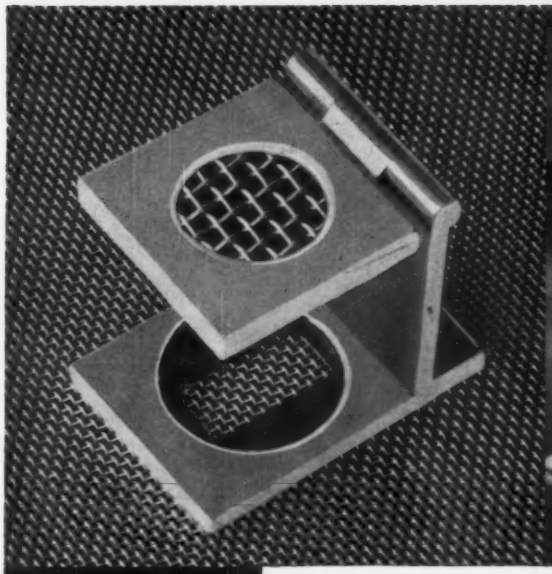

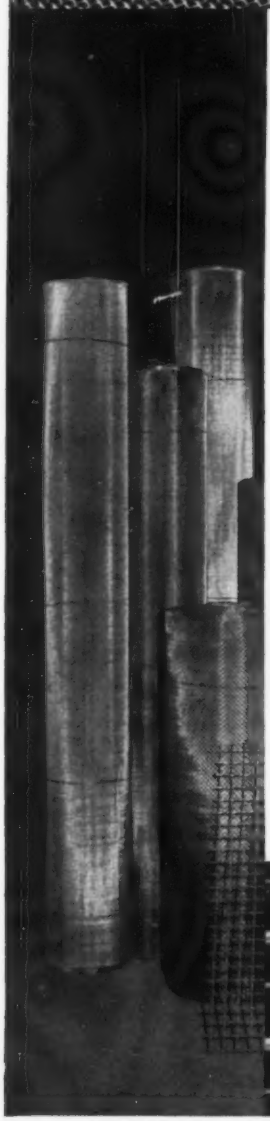

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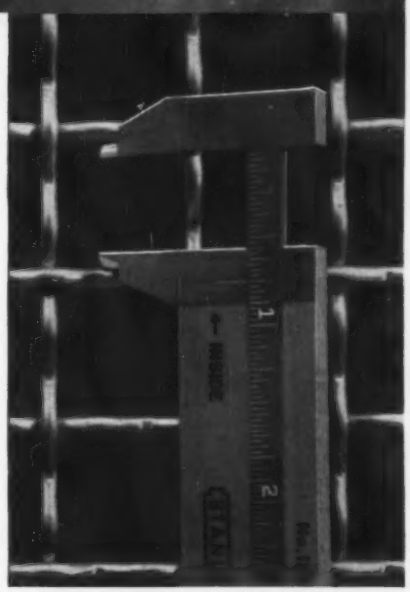

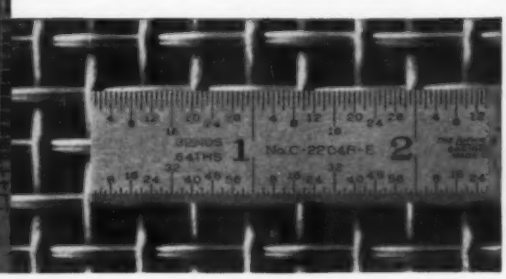

Circle 1547 on Page 48-B

WHEN YOU SPECIFY

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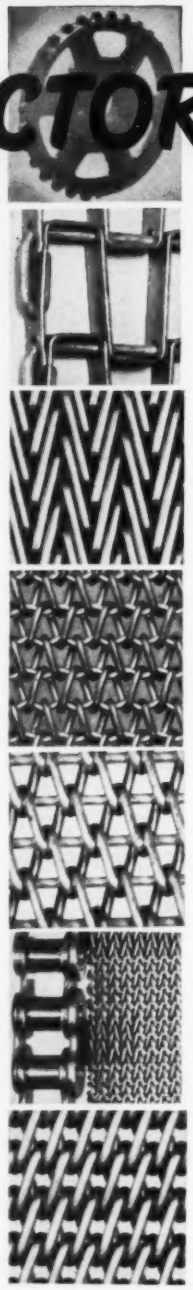

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Technical literature on all Ashworth Metal Process Belts is available at no obligation, write:

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Sales Offices In Principal Cities

Circle 1548 on Page 48-B

Personals . . .

D. M. Lorimer – from research engineer with Boeing Airplane Co., Seattle, Wash., to structures engineer, Lockheed Missiles and Space Div., Palo Alto, Calif.

Walter E. Herman – assigned to West Coast sales of Reactive Metals Inc. (formerly Mallory Sharon Metals Corp.) in Hollywood, Calif.

Arthur C. Willis – from materials laboratory, Temco Missiles & Aircraft in Dallas, Tex., to quality engineer with the Martin Co. Denver division.

Ralph M. Willits – transferred to the Ferndale Refinery as project engineer in charge of design engineering for the 35 M 661 refinery of Mobil Oil Co. as a result of the consolidation of General Petroleum with its parent company.

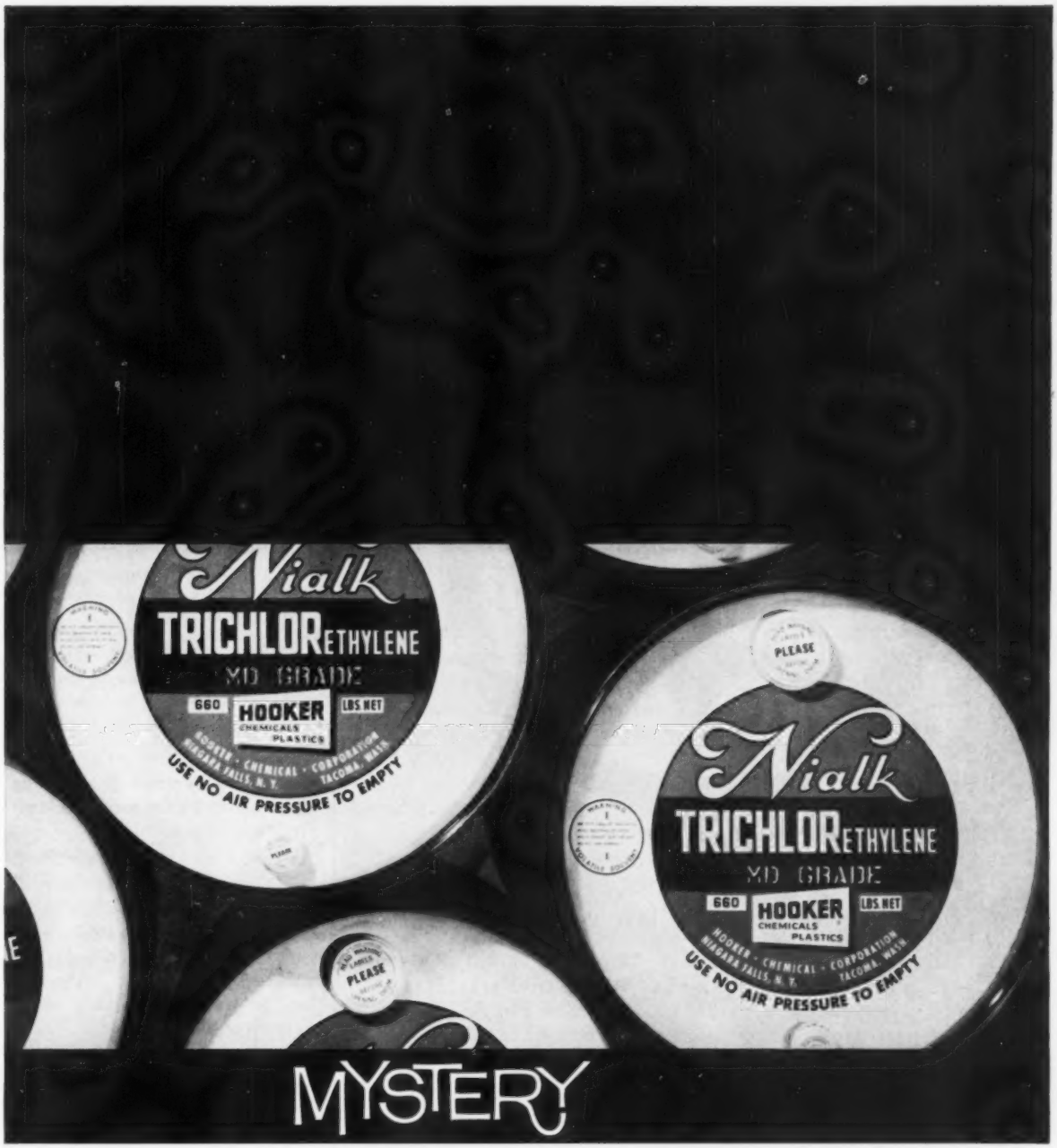
Robert T. Howard – from the University of Kansas City and the James W. Weldon Laboratory to the University of Wichita as professor of engineering.

D. Bruce Masson – now assistant professor in the department of metallurgy of Washington State University and, at the same time, assistant research metallurgist in the division of industrial research of the University's Institute of Technology; he was formerly assistant professor in the department of mechanical engineering at Rice Institute.

D. C. Woodward – currently metallurgical engineer, metals and fabrication division, Fansteel Metallurgical Corp., North Chicago, Ill.

L. H. McCreery – from research specialist, Boeing Airplane Co., Seattle, Wash., to technical specialist (materials), advanced concepts group of development engineering, Temco Electronics & Missiles Co.

Robert R. Reeber – called to active duty as a second lieutenant in the U. S. Air Force, leaving the Radio Corp. of America's Semiconductor Div. in Somerville, N. J. Now a task scientist working on basic research problems in the metallurgy and ceramics laboratory, Aeronautical Research Laboratories, Air Research and Development Command USAF.



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If you would like complete information on Nialk Trichlorethylene, ask for Bulletin 44A and Data Sheet 814. Meanwhile, why not try a few drums (or a tank car) of Nialk brand. You will find that your trichlor dollars buy more at Hooker.

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HOOKER CHEMICALS PLASTICS

Circle 1549 on Page 48-B

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Circle 1550 on Page 48-B

Personals . . .

Robert E. Savage – now foundry industry manager for the primary nickel department of the International Nickel Co., Inc., New York.

Theodore F. Loughry – now manager of foreign operations for Midland-Ross Corp., Cleveland. He was formerly manager of foreign activities for Surface Combustion Corp., which was acquired by Midland-Ross last year.

Stuart A. Smith – from district sales manager in Cleveland for Firth Sterling Inc., Pittsburgh, to general sales manager of the tool and instrument division, Illinois Tool Works, Chicago.

R. W. Guard – now manager, product and process development engineering, diamond products section, metallurgical products department, at General Electric Co. in Detroit.

Clifton J. Huffman – currently manager of the aluminum extrusion plant of Almetco, Inc., a wholly owned subsidiary of Olin Mathieson, Nesquehoning, Pa.

Ernest D. Sevenich – from design engineer at the Jones & Laughlin Steel Corp.'s stainless and strip division plant in Youngstown to project engineer for the division in Detroit.

Gordon R. Gage – from manager of the Edmonton, Alberta, steel warehouse of Dominion Bridge Co., Ltd., to warehouse manager of the Vancouver, B.C., branch.

F. J. Shortsleeve – now director of research, technology department, Union Carbide Metals Co. **E. J. Boyle** and **E. Epremian**, both in the technology department, are respectively, director of development and technical coordinator, New York.

William H. McCormick – from product sales manager, alloy and carbon, Crucible Steel Co. of America, Pittsburgh, to assistant director of metallurgy in charge of customer technical services. Managers of customer technical service are: **M. J. Dempsey**, toolsteels; **K. A. Matticks**, stainless, titanium and high-temperature alloys; and **C. S. Walton**, alloy and carbon steels.

METALGRAMS

UNION CARBIDE METALS

. . . news about metals and metal chemicals

SEPTEMBER - OCTOBER, 1960

VANADIUM BUTTERS TITANIUM-STEEL SANDWICH. A new technique developed by Titanium Metals Corporation of America uses vanadium metal as a "butter" between titanium and steel . . . Counters the usual problem of welding dissimilar metals. Called interlayer welding, this technique uses either a series of vanadium plugs or a thin, continuous sheet. Vanadium metal was selected because it provides the necessary engineering strength and corrosion resistance at the joint. The advance is expected to brighten the cost picture for companies anxious to use corrosion-resistant titanium sheet in chemical processing equipment. UCM makes vanadium metal in sheet or strip for use in the sandwich. Bulletin VM3-P8 gives general data on vanadium and the welding technique.

* * *

MAKING TOOL PRODUCTION TiC. Makers of cemented carbide tools are obtaining greater erosion and oxidation resistance, as well as cost economies, through the use of titanium carbide, TiC. One major tool manufacturer reports simplified quality control because of the consistent analyses of our high-purity material, e.g., free carbon, 0.2%; combined carbon, 19.3%. This refractory compound is also being used in newly developed titanium-carbide-base cutting tools and in cermet and ceramic shapes. UCM's titanium carbide is available in commercial quantities as powder < 5 micron av. FSS. A variation of this product -- submicron high-purity titanium carbide -- is being studied for uses which require fine particle size. Request TC2-P8 for data on TiC.

* * *

VANADIUM AS YOU LIKE IT. As demand for vanadium metal grows, customers look for a wider range of mill products at minimum delivery time. The new focus: manufacture and processing of larger vanadium ingots. An ingot more than 9 in. in diameter -- believed to be the largest to date -- has just been cast for us by Universal-Cyclops. This means more vanadium mill products off the shelf from UCM, as we continue to meet customer requirements in size, as well as purity, with minimum lead time. For data on vanadium request VM2-P8.

* * *

NEW PEAKS PREDICTED FOR POLYPROPYLENE PRODUCTION. Brightest prospects are in over-wrap applications, and in automobile and appliance uses. Keeping step as a polymerization catalyst is our titanium trichloride. Latest interest is in the activated form of this product -- $TiCl_3$-1A -- just introduced. With the activated form, plastics producers are achieving higher conversion rates . . . yet consistently retaining the same clear, high-quality polymer previously provided by the unactivated material. Activated and unactivated titanium trichlorides are available from UCM in quantities for research and commercial uses. For additional data request TT2-P8.

* * *

HELPING OTHERS TO HELP OURSELVES. UCM will be keying its 1960 National Metal Show display to the theme: "Select The Right Metal For The Job...Ask Our Engineers To Help". The fact that alloying elements make metals better will be illustrated by outstanding applications of low-alloy steel, stainless steel, high-temperature alloys, and aluminum. Also featured will be a number of refractory metals with special emphasis on the promising new columbium alloys. To save time and expense send for free Admission Invitation AD1-P8.

* * *

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REFRACTORY PORCELAIN COMPANY
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Circle 1551 on Page 48-B

Personals . . .

John M. Thompson – vice-president and general manager, Itemlab, Inc., Port Washington, L. I., N. Y., where he supervises all activities in research and development, design and testing. For the past ten years he was laboratory chief of the Rome Air Development Center's test facilities laboratory.

J. J. Dvorak – now assistant division head, technical division, Humble Oil & Refining Co., Baytown, Tex.

Robert E. Macherey – from leader of the foundry and fabrication group to associate director of the metallurgy division at Argonne National Laboratory, Lemont, Ill.

Charles A. McFadden – elected vice-president and a member of the board of directors of Bickley Furnaces, Inc., Philadelphia.

Carleton A. German – from general sales manager to vice-president in charge of sales and engineering, Solventol Chemical Products, Inc., Detroit.

Frank W. Davis – currently technical consultant at Southwest Research Institute, San Antonio, Tex. For the past nine years, he had been with the U. S. Atomic Energy Commission in Washington, D. C.

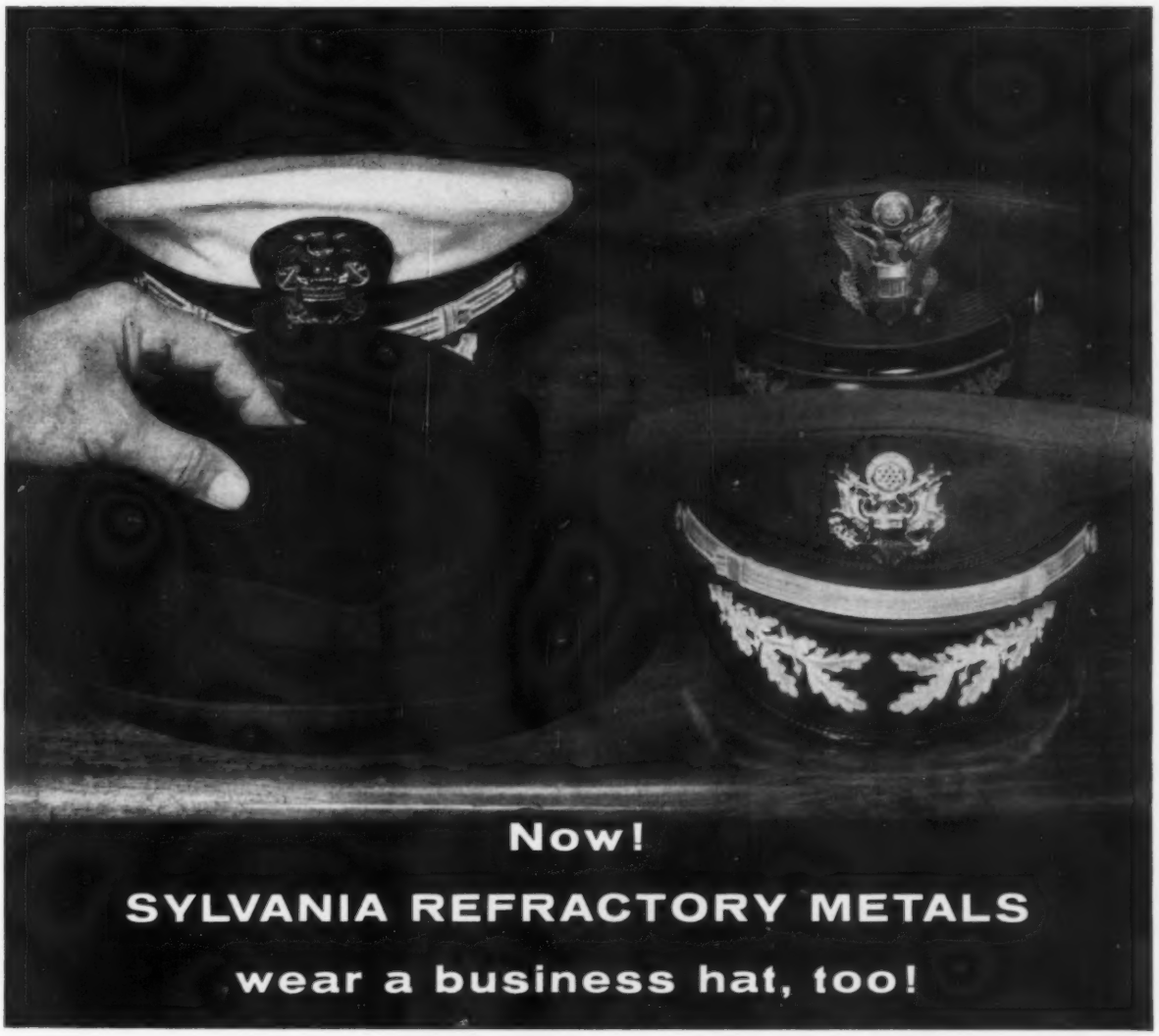
Karl W. Reber – from metallurgist to supervisor of materials testing, M.S.A. Research Corp., located in Callery, Pa.

Bruce S. Old – from vice-president to senior vice-president of Arthur D. Little, Inc., Cambridge, Mass.

Andrew J. Griest – now senior research metallurgist, working on new alloy development in magnetic materials, in the alloy development section of the basic research department, Allegheny Ludlum Steel Corp., Brackenridge, Pa.

Walter I. Weed – from metallurgist to supervisor of quality control at the Detroit plant of Jones & Laughlin Steel Corp.'s stainless and strip division.

Thomas J. Bridgeman – from sales engineer in the Detroit office of Latrobe Steel Co. to assistant sales manager for the Detroit district.



The same top-quality Sylvania tungsten and molybdenum used for government and military projects are now opening up new avenues of applications to all industry!

These metals, able to withstand extremely high temperatures, can be specified in both large- and small-sized billets for arc casting and forging. Or if specifications require, they may simply be machined down to final tolerances.

You can use these metals in an almost endless number of ways. Some of the potential applications are in gas turbines, jet engines, extruded airframe members; and in die-casting dies including hot-work tools, boring bars, tool shanks, and grinding quills. Others include molds and ladles for testing other metals such as iron and steel, plastic-working dies, piercing points, heat-exchanger parts such as piping, heat shields and structural parts for the nuclear energy industry, welding electrodes, and glass-manufacturing equipment.

Take full advantage of the quality Sylvania builds into its tungsten and molybdenum ingots—for *your* products. Write Chemical & Metallurgical Division, Sylvania Electric Products Inc., Towanda, Pennsylvania.

SYLVANIA

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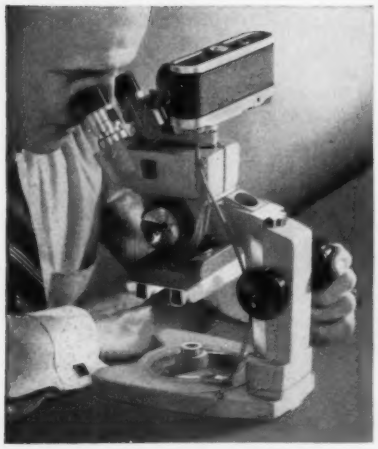
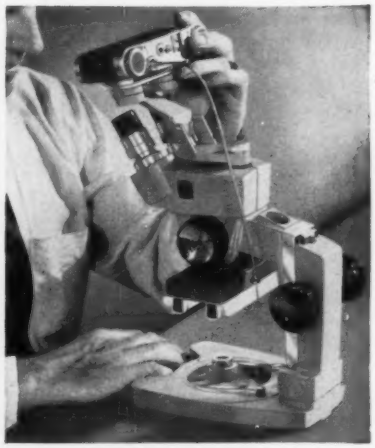
Circle 1552 on Page 49-E

AO Offers Low-Cost Stereophotomicrography

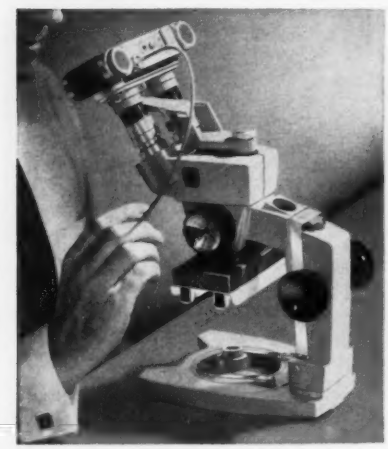
. . . in just three easy steps



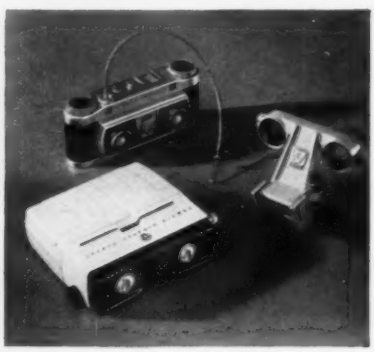
1 SET the focusing adjustment on your AO Spencer Cycloptic Stereoscopic Microscope, to bring specimen into sharp focus. Camera is mounted directly to Cycloptic...out of the way...ready for instant use.



2 SWING the mounted 35 mm Graflex Stereocamera into position over eyepieces. Designed exclusively for Cycloptic, special compensating prisms in adapter unit render camera parfocal with microscopes' optical system. Set camera for bulb exposure. No further adjustment is necessary.



3 SNAP shutter with cable release. You photograph the sharp three-dimensional image exactly as you saw it. Your film processor will supply stereo mounted photographs. Now you have permanent, three-dimensional photomicrographs, in black-and-white or color, for future reference.



The full-size Graflex Stereoviewer, with built-in light source, completes this easy-to-use 3-D photo package. You can review your findings over and over again...anytime ...anywhere. Here is everything you need for three-dimensional photomicrography... unique...easy-to-use. Available only from American Optical.

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☐ Please send full information on AO Spencer 637 Stereocamera attachment.

☐ Also include information on AO Spencer Cycloptic Stereoscopic Microscopes.

Name_____

Address_____

City_____ Zone____ State____

Circle 1553 on Page 48-B

Personals . . .

Albert De Sy, head of the metallurgy department of Ghent (Belgium) University – nominated to the Academy of Science (Royal Flemish Academy of Belgium) and elected honorary member of the Société Francaise de Métallurgie.

Adolph O. Schaefer – formerly president of Pencoyd Steel & Forge Corp. (and past president of the American Society for Metals), now corporation metallurgist for the Struthers Wells Corp., situated in Titusville, Pa.

James A. Barber – from physical metallurgist with Los Alamos Scientific Laboratory to process metallurgist, General Atomic Div. of General Dynamics Corp., located in San Diego, Calif.

Roger E. Wilson – a June graduate of Michigan State University, now associated with pigments, metal products, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

Glen H. Ockenhouse – currently staff metallurgist, central office, ball division, Hoover Ball & Bearing Co., Middletown, Ohio.

Charles L. Wallace – metallurgist, materials development laboratory, Pratt & Whitney Aircraft, East Hartford, Conn.

H. W. Schultze – director of commercial sales and development for the Alloyd Corp., Cambridge, Mass., where he is responsible for the sale and commercial development of vapor-deposited coatings, pure metals and modified deposits. He has been with Alloyd since early this year and before that was manager of new chemical and catalyst development for Climax Molybdenum Co.

W. F. Cartwright, assistant managing director, Steel Co. of Wales Ltd. – elected president of the Iron and Steel Institute for 1960-61.

Kenneth A. DeLonge – now manager, direct sales, in the primary nickel department of the International Nickel Co., Inc., New York.

James R. Getten – after separation from military service, appointed to the staff of the Oak Ridge Gaseous Diffusion Plant.

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Hydrogen in Cold Worked Steel

Digest of "On the Mechanism of Occlusion of Hydrogen By Cold-Worked Hypoeutectoid Iron-Carbon Alloys", by J. E. Werner and H. M. Davis. ⊜ Preprint No. 237, 1960.

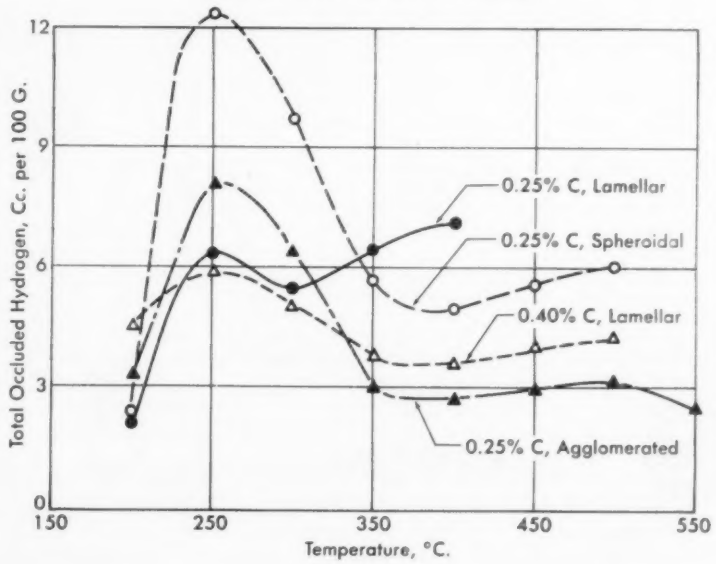
THIS WORK DISPELS the long-held belief that iron-carbon alloys are purely endothermic occluders of hydrogen. Occlusion also occurs by an exothermic process, apparently by sorption on internal surfaces.

The occlusive capacity and the nature of the occlusions were investigated by equilibration of iron-carbon alloys (low-metalloid steels) with oxygen-free dried hydrogen gas between 200 and 400 to 550° C. The experiments comprised use of a fixed volume of steel, vacuum degassing, immersion in hydrogen until equilibrium was reached, and measuring the occluded hydrogen. The iron-carbon alloys were made by pack carburizing a low-metalloid rimmed steel to produce pearlitic alloys containing 0.25 to 0.40% C. Further heat treatment of the 0.25% C steel in a vacuum produced the carbide in the spheroidized and agglomerated (large carbide chunks at the ferrite grain boundaries) conditions. Sheets of each material and condition were cold reduced by 50% reduction in area to provide the cold worked specimens.

Total hydrogen occlusions for all materials and conditions are presented in Fig. 1. Each curve shows a peak in occlusion at 250° C. and a minimum between 300 and 400° C. The negative slopes of the curves from 250° C. to 300 to 400° C. plainly mean that the occlusion in this temperature range is predominantly exothermic. The endothermic occlusion in the positive-slope range, 400 to 500° C. for the cold worked ferrite, is two to three times as great as that reported for annealed steels of the same chemical composition and microstructure (reported by Kotyk and Davis in a companion paper). The negative slope from 500 to 550° C. in the curve for the *0.25% C agglomerated* steel is attributable to ejection of hydrogen on recrystallization of ferrite, and microstructural evidence supports this fact.

The authors were able, by studying the rate of hydrogen rejection and occlusion in the range 250 to 400° C., to show evidence for the coexistence of exothermic and endothermic occlusion. This permitted an estimate of the portion of the total occlusion caused by each mechanism. Further work showed that both mechanisms are reversible. The slow, linear occlusion of hydrogen during the rate experiments is presumably interstitial, as suggested

Fig. 1 — Variation in Hydrogen Contents at Different Temperatures for Four Steels



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Circle 1556 on Page 48-B

Cold Worked Steel . . .

by published work which shows that lattice solution is endothermic and that it increased almost linearly with temperature.

Changes in enthalpy and entropy were calculated for both the exothermic and endothermic mechanism. The entropy data indicate a chemisorbed, monatomic layer of hydrogen atoms for the exothermic process. It also was observed that at any temperature (rising) only a portion of all the exothermally occluded hydrogen is evolved. Chemisorption (rather than physical adsorption) is therefore indicated; in addition, the temperature is too far above the boiling point of hydrogen for an adsorbed layer. Atomic hydrogen presumably is expelled in the exothermic process when the monatomic layer is expelled. One might ask why this hydrogen is not immediately interstitially dissolved by the endothermic process. The authors speculate that much of the released atomic hydrogen may move out along dislocations which may provide channels in the ferrite large enough for easy passage of the atoms.

In summary, between 250 and 400° C. cold worked iron-carbon alloys occlude hydrogen by exothermic and endothermic mechanisms to which the total occluded hydrogen can be apportioned. Both mechanisms are fully reversible. The endothermic occlusion (lattice solution) of hydrogen by cold worked ferrite is several times that of annealed ferrite and the enthalpy increase is two times that of the annealed lattice. The enthalpy decrease for the exothermic process is comparable to that for chemisorption of hydrogen in iron and entropy data also point to chemisorption. Consequently, it is concluded that the exothermic mechanism is chemisorption of hydrogen atoms on internal surfaces created during cold deformation. O. O. MILLER

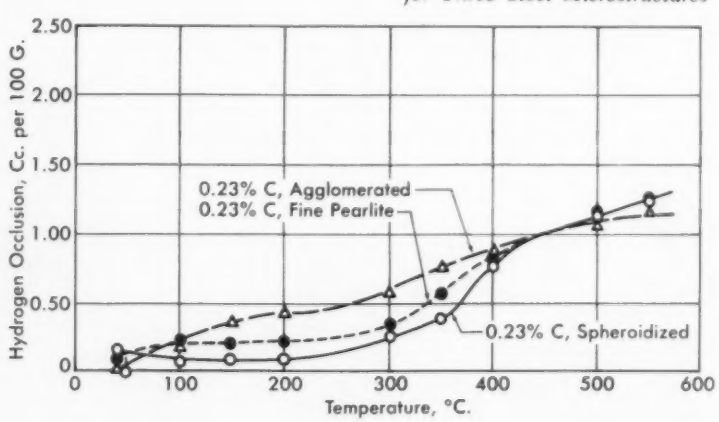
Hydrogen in Annealed Steel

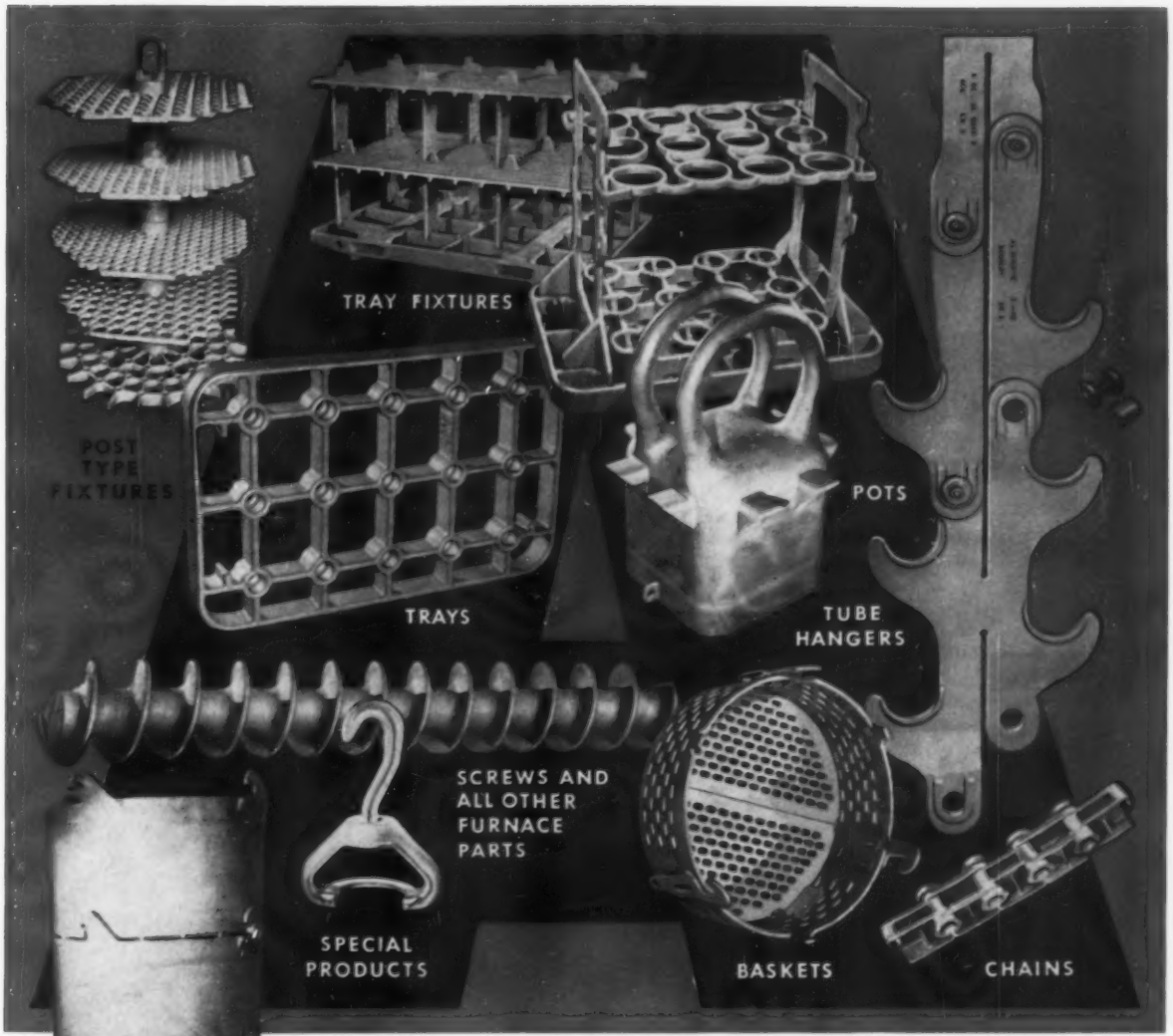
Digest of "The Occlusion of Hydrogen by Annealed Hypoeutectoid Iron-Carbon Alloys", by Michael Kotyk and H. M. Davis. Preprint No. 222, 1960.

THIS WORK WAS AIMED at determining the nature of residence of the hydrogen, and not its effect (which is well known for ferrous alloys). The influence of carbide form and carbon content on occlusion of hydrogen in low-metalloid sheet steel was studied between 40 to 550° C. For the experiments, a sample of steel of fixed volume was vacuum degassed and immersed in hydrogen gas until equilibrium was reached. The occluded hydrogen was then measured. With the resulting data, an effort was made to deduce the relative contribution of three occlusion mechanisms: (*a*) interstitial solution, (*b*) void-volume storage and (*c*) sorption on internal surfaces.

(Continued on p. 180)

Fig. 1 — Variations in Hydrogen at Different Temperatures for Three Steel Microstructures





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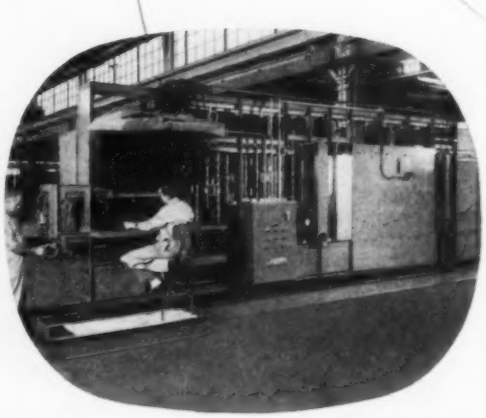

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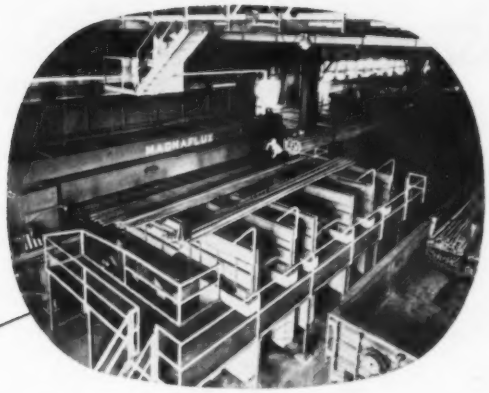

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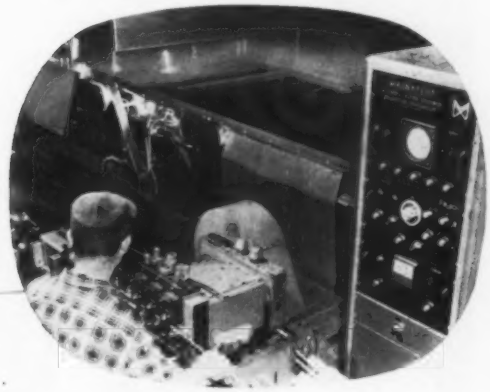

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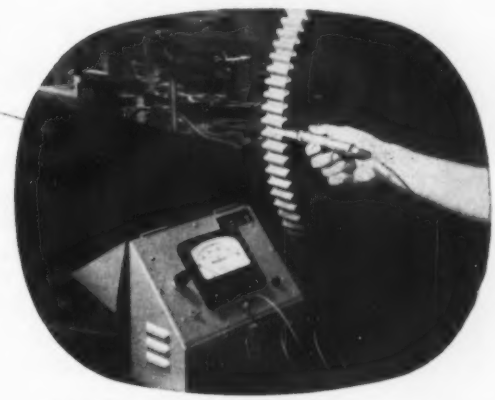

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Circle 1559 on Page 48-B

Annealed Steel . . .

Because of the increasing capacity of iron and its alloys for hydrogen with increasing temperature, they are classified generally as endothermic occluders. Above 400° C., many published data indicate interstitial solution of hydrogen in steel. Below this temperature, however, hydrogen occlusion probably is not entirely interstitial and endothermic. The other two suggested mechanisms are *exothermic.* The first, void-volume storage, probably is of moderate magnitude and decreases slowly with increase in temperature, while the second, sorption on internal surfaces, probably is large initially but decreases rapidly with increase in temperature.

The hydrogen occlusion data on 0.23% carbon steel for three carbide forms are shown in Fig. 1. The agglomerated condition comprises large chunks of carbide at the grain boundaries and represents the coarsest form of the carbide. The fine pearlite and spheroidized conditions are conventional. In Fig. 1, the agglomerated condition shows a gradual increase in hydrogen occlusion between 40 and 550° C. On the other hand, the fine pearlite and spheroidized conditions show nearly unchanging hydrogen occlusion up to 200° C., increase gradually to 400° C., and equal the agglomerated condition above 400° C. Figure 1 shows that the volumes of hydrogen involved in this study of annealed steel are small, ranging from a trace to about 1.25 cc. per 100 g. of steel.

A tentative explanation can be offered for the minimum in the curves for the fine pearlite and spheroidized conditions of Fig. 1. The sorption of hydrogen at the ferrite-cementite boundaries is greatest at low temperatures. As the temperature of the samples is raised above 40° C., the volume of hydrogen desorbed is greater at first than the volume going into interstitial solution. The net result is that hydrogen is expelled to produce a minimum. On the other hand, the agglomerated condition provides only a little sorption, and hydrogen occlusion is largely the result of interstitial solution. This gives a continuous increase in hydrogen content with increase in temperature.

(Continued on p. 192)

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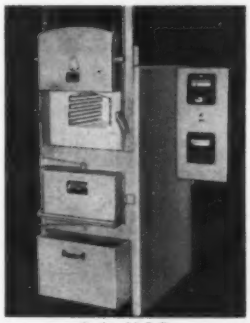

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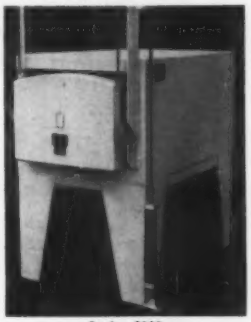

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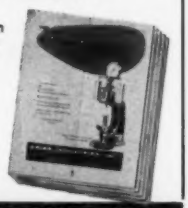

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Complete design facilities for dies or subpress units to press unusual shapes in lab presses.

*PATENTED

HALLER, INCORPORATED
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Circle 51 on Page 48-B

Wiretex BASE TRAYS OUTLAST CAST TRAYS 3 to 1

Another example of how WIRETEX solves special parts holding fixture problems.

Tests at Ford's Indianapolis Steering Gear and Cold Heading plant proved Wiretex fabricated alloy trays saved many dollars, outlast other trays by more than 3 times. 26 months later, the trays were still in use, without replacement.

Call Wiretex for all your heat treating requirements to resist acid, heat, abrasion or exposure.

Specialists in Processing Carriers Since 1932.

Wiretex mfg. co., 20 Mason Street, Bridgeport 5, Conn.

Circle 24 on Page 48-B

RUST-LICK IN AQUEOUS SYSTEMS

Eliminates RUST & Fire Hazards Non-Flammable Non-Toxic

Send for Brochure: The ABC of Rust-Lick for Rust Prevention

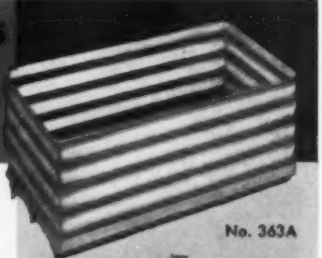
RUST-LICK, INCORPORATED
755 BOYLSTON STREET
BOSTON 16, MASS.

Circle 37 on Page 48-B

✓BASKETS ✓RETORTS ✓CARBURIZING BOXES ✓MUFFLES OF COR-WAL® CONSTRUCTION ARE CUTTING HEAT TREATING COSTS EVERYWHERE!

No. 358

Cor-Wal construction developed by Stanwood engineers has proved its merit in many heat treating departments and commercial heat treating shops. The heat resistant, corrugated rolled alloy metal used in Cor-Wal construction has better loading carrying properties and provides better resistance to thermal stresses—works with the heat, not against it. Send for Bulletin 358.



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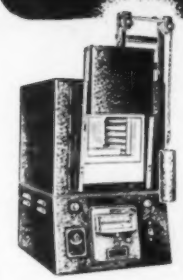
STANWOOD CORPORATION
4817 W. CORTLAND ST., CHICAGO 39, ILLINOIS

Representatives in Principal Cities

Circle 22 on Page 48-B

HUPPERT ELECTRIC FURNACES AND OVENS
for Laboratory and Plant



BENCH MODELS

- Range: 300°F. to 2000°F.
- High temperature, heavy-duty Kanthal elements
- Multi-insulation
- Counter-weighted, tight-sealing door
- Operational pilot light
- Shipped ready to operate

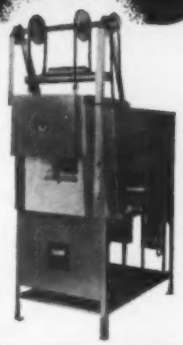
Model No.	Inside Dimensions Wide	High	Deep	KW	Prices 220 Volt Single Phase With Huppert Input Controller	With Electronic Prop. Controller
869	8"	6"	9"	4	$296.00	$480.00
11*	8"	6"	12"	4	306.00	518.00
12*	8"	8"	12"	6	382.00	590.00
12A*	8"	8"	18"	9	490.00	698.00

*For 2300°F. add $95.00 to No. 11 and No. 12, and $105.00 to No. 12A. No. 12A can be furnished for 3 phase at no additional cost. For floor model add $52.00 to above prices. No. 869 standardly supplied for 2200°F.

FLOOR MODELS
28 Standard Sizes

- Continuous operation to 1850°F.—intermittent to 1950°F.—for 2300°F. on special order.
- Complete with automatic electronic controller.
- Tight-sealing, wedge-type door.
- Multi-insulation for maximum efficiency.

Shipped Ready to Operate
Model No. 16 Illustrated $1050.00



Also Special Models for Specific Requirements. Special KR-Supers to 3100°F.

K. H. HUPPERT CO.
Manufacturers of Electric Furnaces and Ovens For A Quarter Century
6844 Cottage Grove Ave., Chicago 37, Illinois

Request new catalog on furnaces, ovens, data, prices.

Circle 53 on Page 48-B

All The Best

HEAT RESISTING ALLOYS

Ready When You Need Them

Please Send for Stock List and Literature

ROLLED ALLOYS, INC.
Heat and Corrosion Resistant Alloy Specialists

5309 Concord Avenue • Detroit 11, Michigan
Phone WAlnut 1-4462

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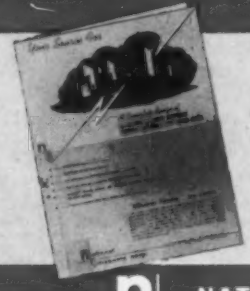
Phone CLifford 4-4616

Circle 44 on Page 48-B

FREE! ULTRASONIC CLEANING BULLETIN



Describes National Ultrasonic Corporation's:

- Applications Laboratory service. Your sample parts are cleaned ultrasonically and equipment and cost recommendations are made at no charge.
- STANDARDLINE medium power cleaners for all applications requiring average energy levels.
- HEAVYDUTYLINE high power cleaners for industrial applications requiring high energy density.
- NUclean® solvents and detergents especially formulated for ultrasonic cleaning.

NATIONAL ULTRASONIC CORP.
111 Montgomery Ave., Irvington 11, N. J.
ESsex 1-0550 • TWX NK 1030

Circle 31 on Page 48-B

Positive, Portable Lightweight (7 lbs.)

FINDS CRACKS INSTANTLY!

genuine **MAGNAFLUX Y-5 YOKE KIT**

Everything you need for Magnaflux testing: Yoke, gray dry powder and red prepared bath, cleaner, instructions, etc. Metal carrying case.

$195.00
Users net price F.O.B. Chicago

For maintenance overhaul, or even certain production inspection get the real Magnaflux in its most convenient form! Just right magnetizing power—light, easy to handle 7 lb. yoke, greatest accuracy and repeatability of results—Use indoors or out from 115V. A.C. or a 12V. battery—Handles hard-to-reach parts or areas.

USE MAGNAGLO and BLACK LIGHT

For the fastest, most sensitive tests, it can also be used with pressure spray cans of Magnaglo and black light. Kits available at modest cost.

Order From Your Distributor, or Direct
MAGNAFLUX CORPORATION
A Subsidiary of General Mills
7328 W. Ainslie Avenue, Chicago 31, Illinois

Circle 52 on Page 48-B

Whitelight
MAGNESIUM

your comprehensive independent mill source of magnesium alloy . .

ALLOYS
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AZ31
AZ51
AZ61
AZ81
ZK60
ZK30
M-1
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Anodes

RODS ¼" dia. to 6½" dia.
BARS, STRIPS .022" min. to 7¾" max
SOLID SHAPES .022" min. to 6½" circle
TUBING ¼" O.D. to 6" O.D.
HOLLOW SHAPES ¼" to 6½" circle
PLATE & SHEET .092" to 3" thick

WHITELIGHT MAGNESIUM

WHITE METAL ROLLING & STAMPING CORP.
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Factories: Brooklyn, N.Y. • Warsaw, Ind.
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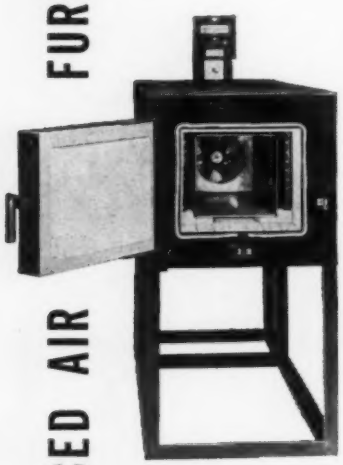
Circle 1 on Page 48-B

LUCIFER FORCED AIR FURNACE



The Lucifer Furnaces, Inc., Series 4055 furnaces are manufactured in 25 standard models with 800° F. or 1250° F. maximum operating temperatures. These furnaces are designed for tempering, drawing, heat treating aluminum, and glass annealing. Each furnace is a complete unit . . . controls included. They are equipped with a large fan and motor to force circulation of air in the working chamber to insure maximum uniformity of temperature.

All electric heat treating furnaces by Lucifer feature • low initial cost • low upkeep • top production performance • minimum replacement downtime. For free engineering advice, parts, or product information . . . write, wire or call . . .

LUCIFER FURNACES, INC.
Neshaminy 7, Penna.
Diamond 3-0411

Circle 26 on Page 48-B

SORGEL
Saturable Reactors

Saturable Reactor with tap changing transformer

Regulate and control electric ovens and furnaces more accurately and efficiently

Any amount of A.C. power from 1 Kva to 3000 Kva, single phase or 3-phase, at any voltage, can be controlled, regulated, and varied in stepless increments, with SORGEL Saturable Reactors.
The control can be a small manually operated hand wheel that can be placed in any desired location, or it can be automatically controlled, regulated and varied by a thermostat or any other instrument or device.
SORGEL reactors are designed to meet your exact requirements. Let us know what your problems and requirements are, and we will submit our recommendations with complete information.

Write for Bulletin 658.

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Also a complete line of dry-type transformers.

All standard and intermediate ratings, ¼ Kva to 10,000 Kva, 120 to 15,000 volts.

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Sales Engineers in principal cities

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Sorgel Electric Company

834 W. National Ave., Milwaukee 4, Wis.
Since 1916 devoted to creative engineering and manufacturing craftsmanship

Circle 16 on Page 48-B

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HOOVER
SPECIALISTS IN THE FIELD OF
Die Castings
SINCE 1922
Aluminum and Zinc

HOOVER

THE HOOVER COMPANY
Die Castings Division
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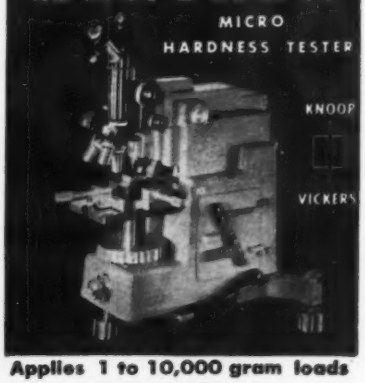
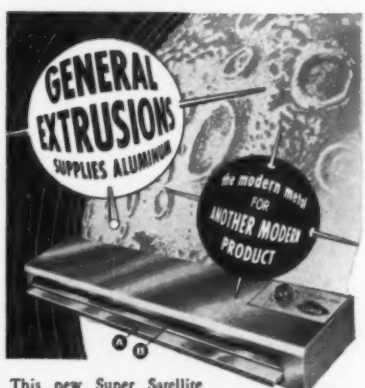
Circle 41 on Page 48-B

KENTRON
MICRO HARDNESS TESTER



Applies 1 to 10,000 gram loads
Write for Bulletin
Kent Cliff Laboratories Div.
The Torsion Balance Company
CLIFTON NEW JERSEY

Circle 19 on Page 48-B



This new Super Satellite rotary diazo printer is acclaimed by draftsmen as the fastest white-printer in the low price field. Made by Grico, Inc., of Cuyahoga Falls, Ohio, its feedboard (A) and paper guide (B) are aluminum, extruded, polished and anodized by General Extrusions, Inc.

GENERAL EXTRUSIONS, INC.
4040 Lake Park Road • Youngstown, Ohio
Sales Offices at St. Louis, Pittsburgh, Chicago, Cincinnati, Cleveland and Chattanooga

Circle 2 on Page 48-B

ROUND, SQUARE, FLAT AND HALF-ROUND WIRE FOR MASS PRODUCTION OF SMALL PARTS

Beryllium Copper • Bronzes
Other Non-ferrous Alloys
Rounded or square edges.
Available with hot-tinned finish for solderability.
Write for descriptive folder.

LITTLE FALLS ALLOYS
INCORPORATED
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Circle 40 on Page 48-B

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EPOXY GUIDE

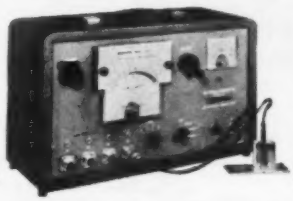
Interested in modernizing your production? Get this handy reference guide on epoxy adhesives, coatings, sealants, and plastic alloys . . . without cost or obligation.

Just write us on your company letterhead and ask for a complimentary copy of Resiweld Book #2.

RESIWELD
H. B. Fuller Co.
ST. PAUL , MINN.

Circle 34 on Page 48-B

THE NEW
DERMITRON
NON-DESTRUCTIVE COATING THICKNESS TESTER



FAST . . . ACCURATE NON-DESTRUCTIVE DIRECT-READING

- Instantly measures the thickness of metallic and non-metallic coatings and films
- Based on eddy-current principles
- Enables measurements on small or otherwise inaccessible areas

This portable instrument for both laboratory and production use, gives fast, accurate and direct readings of virtually any coating on any base, including:

- Metal coatings (such as plating) on metal base (magnetic and non-magnetic)
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- Metal films (such as vacuum metallizing) on non-metallic base (plastics, ceramics)

Write for latest bulletins and questionnaire to help solve your thickness testing problems

UNIT PROCESS ASSEMBLIES, INC. UPA

Circle 54 on Page 48-B

revolutionary • low cost
Newage
MICROHARDNESS TESTER

- permits direct, accurate readings corresponding to Vickers within a few seconds
- ideally suited for on-the-job production work
- eliminates a microscope, conversion charts, complicated tables
- for rapid and accurate checking of surface layers, thin sheets, flat springs, instrument parts, wire punches, etc.
- can be obtained in 1 kg or 2 kg loads penetrating as little as .000079" or .00016" respectively

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JENKINTOWN, PA.
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Write, wire or call for full details

Circle 55 on Page 48-B

RAMCO
modular power spray washers

☑ MAXIMUM PERFORMANCE
☑ MAXIMUM ECONOMY

Proof? In this Ramco Bulletin . . . shows how you can create the *right* system for today's . . . and tomorrow's needs. *Send for your copy NOW!* Ask for Bulletin 659-1.

RAMCO EQUIPMENT CORP.
DIV. OF RANDALL MFG. CO., INC.
809 Edgewater Rd. • New York 59, N.Y.

Circle 42 on Page 48-B

LA-CO
Aluminum Soldering Flux
Now . . . Solder Aluminum with ordinary soft solders

- Use 60-40, 50-50, 40-60, 95-5 solders
- No new soldering techniques
- Non-acid . . . Self-cleaning

A major breakthrough in aluminum fabrication. Use ordinary soft solders . . . ordinary irons or torches. Remarkable fluxing action achieves perfect bond of aluminum and solder making possible the fabrication of aluminum to aluminum, copper, steel, stainless steel, galvanized iron, brass, etc.

Write for sample, or engineering help on any fluxing problem.

LAKE Chemical Co.
3079 W. Carroll Ave.,
Chicago 12, Ill.

LA-CO
Silver Solder Flux
Greater speed and economy for all silver soldering!

- Packed in tins
- Will not harden
- Non-acid . . . Self-cleaning

For all silver soldering in 1125° to 1700° F. heat range. Dissolves all refractory and non-refractory oxides . . . solder penetrates completely into all areas, for maximum strength without solder waste. Completely acid-free—will not pit or stain metals. Always-ready paste form . . . will not harden or crystallize.

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LAKE Chemical Co.
3079 W. Carroll Ave.,
Chicago 12, Ill.

LA-CO
Stainless Steel & Chrome Soldering Flux
Safer . . . Surer . . . Cleaner

- Doesn't stain
- Non-acid
- Self-cleaning

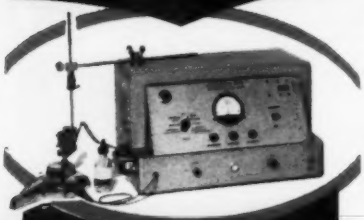
For soldering all stainless steel and chrome, including 300-400 Series, with ordinary soft solders. Requires no pre-cleaning. Acid-free formulation will not pit metals, leaves no stains. No buckling on even light gauge work. In liquid or paste form.

Write for sample, or engineering help on any fluxing problem.

LAKE Chemical Co.
3079 W. Carroll Ave.,
Chicago 12, Ill.

TESTING PLATING THICKNESS?

15 Day FREE Trial
Guarantees Satisfaction



KOCOUR ELECTRONIC THICKNESS TESTER MODEL 955

Model 955 determines the thickness of decorative and heavy chromium, silver, tin, cadmium, zinc, brass, copper, nickel, lead, and other metallic deposits on various base metals. 90 - 95% accurate . . . Direct reading . . . simple operation.

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CHICAGO 32, ILLINOIS

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BOLTS & CAP SCREWS
SOCKET, SET & CAP
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MACHINE SCREWS
SHEET METAL SCREWS
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PIPE FITTINGS

Star Stainless screws have clean—bright—shiny—heads

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Circle 43 on Page 48-B

All that 'Quality' and 'Service' imply are yours with:

PRODUCTS OF TECHNIC RESEARCH for Precious Metal Plating

OROTHERM HT
Heat resistant 24Kt Acid Bright Gold, extremely low porosity, hard and ductile

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24Kt Acid Bright Gold, tight grain, superior throwing and leveling power

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23+Kt Low Stress, Hard and Bright operates at room temperature, without free cyanide

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For High Purity, Low Stress fine grain Rhodium electroplating

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A Superior Platinum concentrate for better plating

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A highly efficient soluble Palladium for plating at room temperature

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Anionic detergent for free rinsing and cleaning

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Quality controlled and custom packaged to suit your requirements

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For semi-conductor plating

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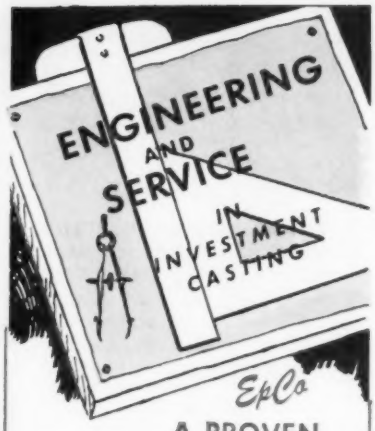

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A PROVEN DEPENDABLE SOURCE
FOR BETTER GRADE INVESTMENT CASTINGS IN FERROUS AND NON-FERROUS METALS

INVAR CASTING
Special Feature — Nickel content held to 35% minimum — 36% maximum

STAINLESS STEEL PART for milk bottling unit formerly machined from solid stock. Only finish operations required are reaming small dia. of counterbored hole and drilling and tapping for set screw.

ENGINEERED PRECISION CASTING CO.

MORGANVILLE, N. J.

Circle 15 on Page 48-B

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ULTRA-LOW TEMPERATURE CABINETS

for
- Research
- Storage
- Seasoning
- Testing

Seven styles . . . chest capacities from 1.5 to 6 cu. ft. Uprights up to 22 cu. ft. Temperatures to —140° are controllable within 1°. Immediate delivery.

For FREE folder, "Selecting a Low Temperature Cabinet," write Revco, Dept. MP-100.

Industrial Products Div.
REVCO INC
Deerfield, Michigan
Setting Trends in Refrigeration Since 1938

Circle 12 on Page 48-B

TENSILKUT

Pat. Pend., U.S., Canada

● Now with TENSILKUT, whatever your testing methods or materials, you can have perfect precision machined physical test specimens in less than two minutes.

● TENSILKUT precision machines all foil, film, sheet and plate metals . . . from .0005" foil to .500" plate. Hard .001 stainless steel foil to soft ½" aluminum, soft plastic film 1 mil in thickness or the abrasive glass laminates in .500" plate, are machined with specimen configurations accurate to ± .0005". Machined edges are completely free of cold working or heat distortion and require no hand finishing.

● TENSILKUT table and floor models are available with motors from ½ to 2½ h.p. Write for free brochure.

SIEBURG INDUSTRIES INCORPORATED
Danbury Industrial Park, Danbury, Connecticut
Circle 11 on Page 48-B

HARDNESS TESTING
SHORE SCLEROSCOPE

Pioneer American Standard Since 1907

Available in Model C-2 (illustrated), or Model D dial indicating with equivalent Brinell & Rockwell C Hardness Numbers. May be used freehand or mounted on bench clamp.

OVER 40,000 IN USE

SHORE INSTRUMENT & MFG. CO., INC.
90-35M Van Wyck Exp., Jamaica 35, N.Y.
Circle 10 on Page 48-B

FREE

***the* QUENZINE STORY**

Low priced, more readily available carbon steels can often replace alloy steels when quenched in Beacon Quenching Oils with QUENZINE added. For information on this new additive and other Beacon Brand Heat Treating Compounds write to . . .

ALDRIDGE INDUSTRIAL OILS, Inc.
3401 W. 140th St., Cleveland 11, Ohio
Circle 29 on Page 48-B

Solve
Inspection
Sorting
Demagnetizing
Problems
with
MAGNETIC ANALYSIS...

MULTI-METHOD EQUIPMENT

Electronic equipment for non-destructive production inspection of steel bars, wire rod, and tubing. Detects mechanical faults and variations in composition and physical properties. Average inspection speed — 120 ft. per minute.

MULTI & SINGLE FREQUENCY EQUIPMENT

Eddy current equipment for non-destructive testing of non-magnetic metal tubing, bars, wire, ⅛" to 3" dia. at test speeds from 200 to 600 fpm. Multi-frequency unit offers 6 simultaneous inspection methods to indicate surface and subsurface flaws, or variations in mechanical, physical, and metallurgical properties. The single frequency unit offers one inspection method to indicate flaws only.

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COMPARATORS AND METAL TESTERS

Electronic instruments for production sorting of both ferrous and non-ferrous materials and parts for variation in composition, structure and thickness of sheet and plating.

DEMAGNETIZERS

Electrical equipment for rapid and efficient demagnetizing of steel bars and tubing. When used with Magnetic Analysis Multi-Method Equipment, inspection and demagnetizing can be done in a single operation.

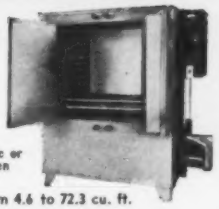
MAGNETISM DETECTORS

Inexpensive pocket meters for indicating residual magnetism in ferrous materials and parts.

"THE TEST TELLS"
For Details Write:
MAGNETIC ANALYSIS CORP.
42-44 Twelfth St., Long Island City 1, N. Y.
Circle 7 on Page 48-B

UNIFORM HEAT
throughout the work space

30 STANDARD CABINET MODELS



Model HB Electric or Gas Cabinet Oven

- Work space from 4.6 to 72.3 cu. ft.
- Temp. ranges from 100 to 1250° F.
- Electronic combustion devices for gas models
- Indicating control instrument
- Factory tested

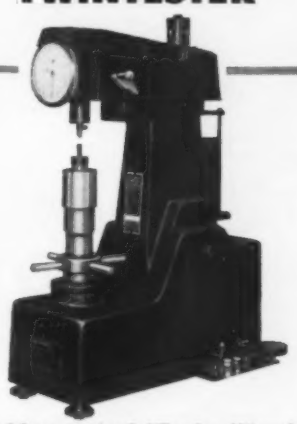
Other ovens from $121.50 up; laboratory, bench, walk-in and custom built models.

Write for details

Specialists in Heat Process Equipment

GRIEVE-HENDRY CO. Inc
1339 N. Elston Ave. Chicago 22, Ill.
Circle 21 on Page 48-B

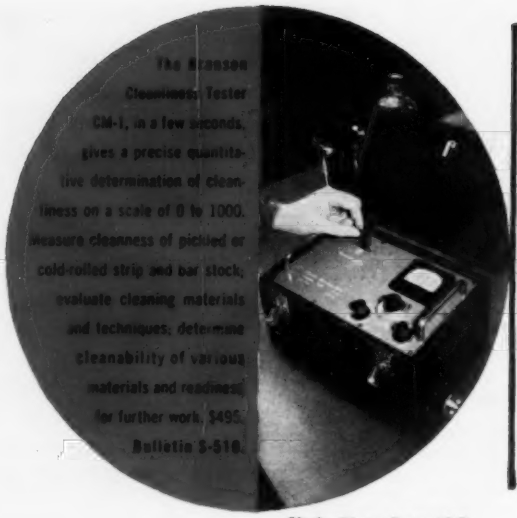
Wilson "Rockwell" TWINTESTER



- Measures both "Rockwell" and "Rockwell" Superficial hardness on B, C, N, T and other scales
- Easy to operate—change from "Rockwell" to "Rockwell" superficial testing in seconds
- Large direct-reading dial with one zero set position for all scales
- Complete equipment includes cowl, ball penetrator for B and T scale, "Rockwell" test blocks, anvils, dust cover, and protective sleeve set
- Complete line of accessories available

Write to Dept. DU. Ask for Bulletin TT-59

WILSON "ROCKWELL" HARDNESS TESTERS
Wilson Mechanical Instrument Division
American Chain & Cable Company, Inc.
230-F Park Avenue, New York 17, N.Y.
ACCO
Circle 45 on Page 48-B


The Branson Cleaniness Tester CM-1, in a few seconds, gives a precise quantitative determination of cleanliness on a scale of 0 to 1000. Measure cleanness of pickled or cold-rolled strip and bar stock; evaluate cleaning materials and techniques; determine cleanability of various materials and readiness for further work. $495. Bulletin S-518.

DO YOU KNOW...

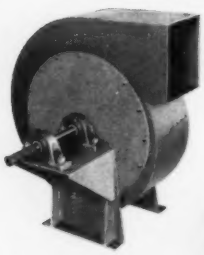
HOW CLEAN IS CLEAN?

BRANSON ULTRASONIC CORPORATION
6 Brown House Rd., Stamford, Conn.

Circle 33 on Page 48-B

Low maintenance cost on

GARDEN CITY FANS



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RF Thermal-Aire Fans
High temperature fans for recirculation, exhaust, induced draft. Handle hot air or gases to 2000°F. Bulletin RF 589-H.

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Special problem?
Ask us about Garden City's Custom-Built Fans

GARDEN CITY FAN & BLOWER Co.
ESTABLISHED 1879
813 North Eighth St., Niles, Michigan

Circle 57 on Page 48-B

TEST HIGH-LOW ELONGATION WIRE MATERIALS

VERSATILITY AND ECONOMY are key features of the Scott Model CRE Electronic Tester. You get ultra-high accuracy of inertialess electronic weighing . . . plus effortless, error-free, push-button testing of wire products *at amazingly low cost!* Stress-strain information "picturized" on strip chart. Ample magnification for detailed analyses of wire, insulation sheath, cable components. Interchangeable test capacities to 1000 lbs. For facts on Model CRE Tester, write **Scott Testers, Inc., 187 Blackstone St., Prov., R. I. Tel: DExter 1-5650 (Area Code 401).**

SCOTT TESTERS
THE SURE TEST... SCOTT!

Circle 58 on Page 48-B

How to Cut Pot Costs:

Buy low-cost Eclipse pressed (not welded) steel pots . . . and replace them on a regular schedule.

1 Lower initial cost
2 Elimination of failures
3 Faster, more even heating
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Guaranteed free from defects. Write:
Eclipse Fuel Engineering Company
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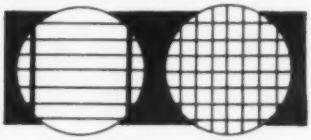
Eclipse PRESSED STEEL POTS

Circle 27 on Page 48-B

4 MORE REASONS YOU SHOULD TRY...

bixco FABRICATED HEAT-TREAT BASKETS

1 MORE OPEN AREA
Our unique looped wire liner (with slotted openings) affords 30% to 100% greater open area than conventional liners. Faster heats, greater circulation of atmospheres and more uniform quenches are a direct result.



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In the Economy 6 Series with built-in liner and round rod framing, total basket weight is kept to an absolute minimum without sacrificing high strength.

3 TRUE ECONOMY
Our many exclusive features bring basket maintenance and furnace operating costs DOWN. Bixco baskets perform better because they are made better.

4 SPACE AGE ENGINEERING
Meeting the demands for better baskets is a Bix Company specialty. Besides fabricating in all standard metals we also produce baskets of Molybdenum. Special designs and applications are available on request.

For complete information write:

bix COMPANY
FAIRGROUNDS ROAD
WELLINGTON, OHIO

Circle 25 on Page 48-B

Bright solution for a bright annealing problem

The non-magnetic stainless steel parts above are used by Waterman Products Company, Philadelphia, Pa., in electron tubes. They are bright annealed at 1150 C (2102 F) maximum temperature in a dry hydrogen atmosphere on a 15 minute cycle. The furnace employs an Inconel muffle, water cooled at the rear for quick cooling of the work.

Since close, uniform temperature control and utmost cleanliness are necessary, electric heat offers obvious advantages. Ordinary ribbon elements, however, have a working limit of about 1150 C (2102 F)—too close to the maximum temperature used for practical operation.

What's the answer? The Waterman Products Company solves the problem by having the parts annealed in a 40 kilowatt electric furnace designed and built by the Drever Company, Bethayres, Pa., equipped with GLOBAR® silicon carbide heating elements.

GLOBAR elements can be used with safety to above 1510 C (2750 F). There are no combustion products to cause problems. There are no stack losses, and radiation loss is reduced to a minimum through the use of insulating refractories. The result is greater efficiency and a cooler shop. GLOBAR elements, moreover, make possible a simpler, more compact furnace, saving space and expense.

The advantages of heating with GLOBAR elements often more than cancel out differentials in Btu costs between electricity and other fuels. Why not investigate with your furnace builder—or write to Refractories Division, Globar Plant, Dept. MP-100, The Carborundum Co., Niagara Falls, N. Y.

For latest advances in silicon carbide heating elements... count on

CARBORUNDUM®

Circle 1614 on Page 48-B

For precise, economical electric heating

GLOBAR silicon carbide heating elements

- Shipped from stock or within two weeks.
- Temperatures from 1400 to 2800 F, precisely controlled, independent of atmosphere.
- Easily replaced from outside without waiting for furnace to cool.
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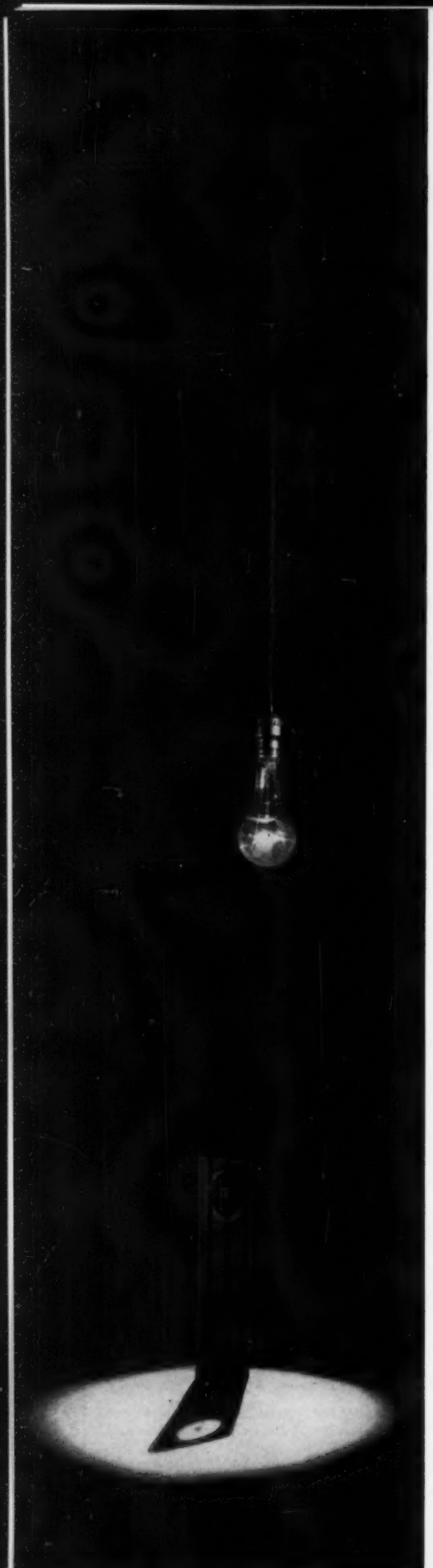
- Elements 4" to 105" in length.
- For greater economy in heat treating, brazing, forging, melting, and sintering.



One of a series

New Light on a Compound Semiconductor

Pictured is a new and unusual transistor . . . made from a *compound* semiconductor. Its electronic properties are greatly affected by *light*. It is a *field-effect* transistor having input impedances up to 100 megohms (versus 1,000 ohms for junction transistors). Its unique combination of properties has enabled it to perform some novel circuit functions not possible with other transistors.

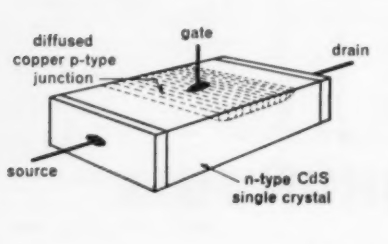
Still in the early experimental stage, this phototransistor is a tangible result of the General Motors Research Laboratories' program on semiconductors – particularly the group II-VI compound, cadmium sulfide. Behind its development lies the steady accumulation of (1) know-how in crystal growing, doping, and contact preparation and (2) information about CdS's intriguing solid state properties (red or green luminescence, high photoconductivity, short relaxation times, etc.).

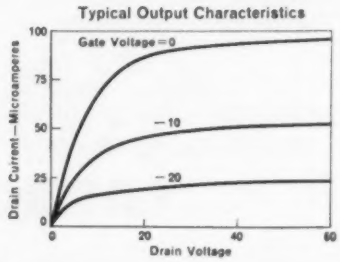
For the researcher, this three-terminal device is adding a new dimension to the fundamental understanding of semiconductors. For instance: GM Research scientists have uncovered the important role of photo-generated holes in modulating the conductance of this intrinsic semiconductor and have determined the hole drift mobility through a new theoretical analysis.

These semiconductor investigations illustrate the dual aim of GM Research: contributions to the science, advances in the technology of important new subject areas. Such research is the initial step in General Motors' continuing quest for "more and better things for more people."

General Motors Research Laboratories

Warren, Michigan





Circle 1613 on Page 48-B

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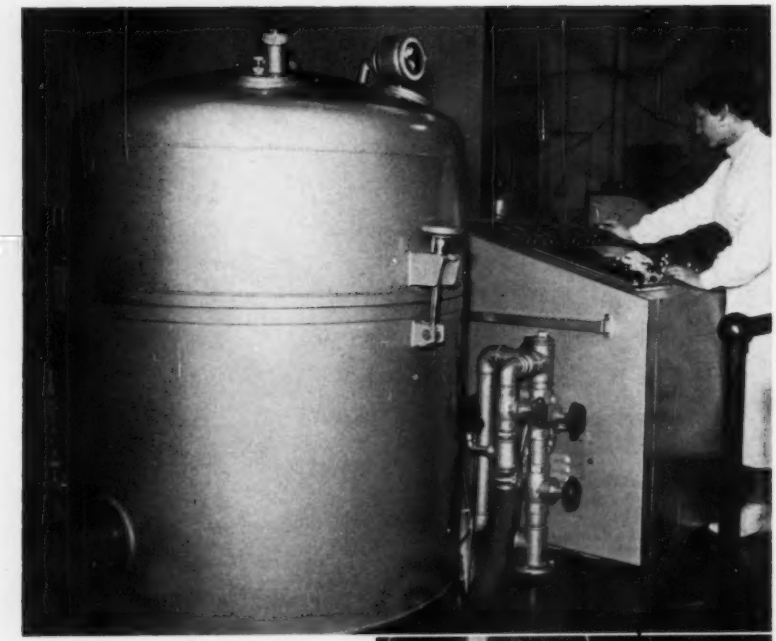
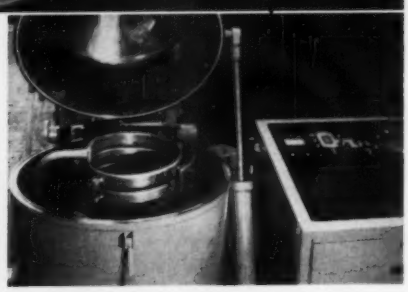
Circle 1560 on Page 48-B





Sinter in Vacuum up to 3,000° C!

Water-cooled, wear-free induction coils produce electro-magnetic field for fast, uniform heating.

Centigrade, notice, not Fahrenheit. This temperature has many times been achieved, and maintained, under laboratory conditions with Heraeus Induction Sintering Furnaces. In production, temperature range of 2,600°C to 3,000°C is typical.

More significant, these Heraeus furnaces improve end product quality while cutting operating costs. You get uniform heat distribution . . . faster heating . . . and longer element life . . . than with any other vacuum furnace on the market today.

There's a complete line to meet your needs, with coil diameters from 6¾" to 20½" . . . with choice of pumping systems for working pressures from atmosphere down to the 10^{-5} range. Each gives you complete facilities for the widest range of vacuum metallurgy: sintering, reactive work, degassing, purification of metal powders, brazing, annealing, hardening. Each saves the high cost of constantly replacing the expensive elements required in resistance heating.

Find out more about higher quality work, lower operating costs. Write for Bulletin 4-25.

Consolidated Vacuum Corporation

ROCHESTER 3, NEW YORK

Circle 1561 on Page 48-8

Annealed Steel . . .

The occlusion capacity of the steel for hydrogen varies little with carbon content from 0.015 to 0.54%. Hydrogen occlusion - temperature curves for this work (not shown graphically in this digest) confirm that the microstructural differences in Fig. 1 are much more potent than differences in carbon content.

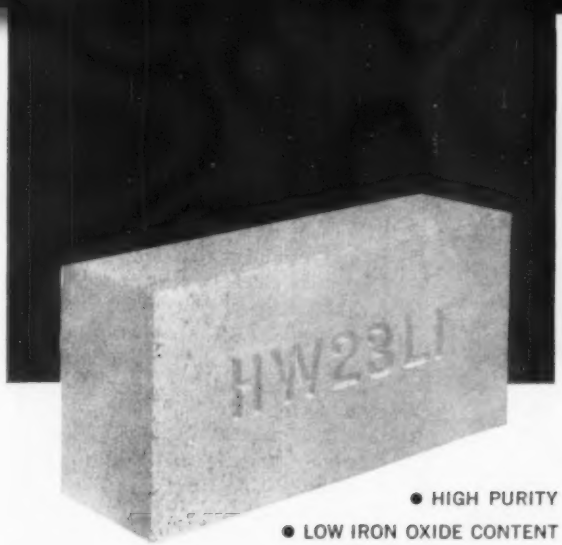
The average slope of the occluded hydrogen-temperature curves in the range 400 to 500° C. indicate 6.5 Kcal. per gram-formula weight of hydrogen atoms for the enthalpy of endothermic occlusion. Inasmuch as this figure is in close agreement with published data for solution of hydrogen in unalloyed ferrite, it is concluded that occlusion of hydrogen by the iron-carbon alloys at temperatures above 400° C. does not involve the carbide phase.

In summary, hydrogen occlusion at 400° C. and above is endothermic, and is attributed to interstitial solution in the ferrite lattice, apparently without involving the carbide phase. Minimums in some occlusion curves between 40 and 200° C. are the net result of decaying exothermic occlusion and increasing endothermic occlusion. The mechanism of the main exothermic process is believed to be sorption at the cementite-ferrite or pearlite-ferrite interfaces. Thus microstructure (carbide form) exerts a strong influence on occlusion in this range. O. O. MILLER

Cylindrical Textures

Digest of "Cylindrical Textures in Tungsten and Other Body-Centered Cubic Metals", by S. Leber. ● Preprint No. 225, 1960.

PREVIOUS INVESTIGATIONS of preferred orientation in wiredrawn materials have raised a slight controversy concerning the possible types of texture formed. Conclusive evidence for the proper differentiation of the fiber texture from the cylindrical texture is missing. While both textures (see Fig. 1) show a preference for the <110> direction parallel to the wire axis, the (100) planes in the cylindrical texture tend to be parallel to the surface of the wire, while they are oriented at random in the fiber texture.



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insulating fire brick particularly suited for controlled atmosphere furnaces

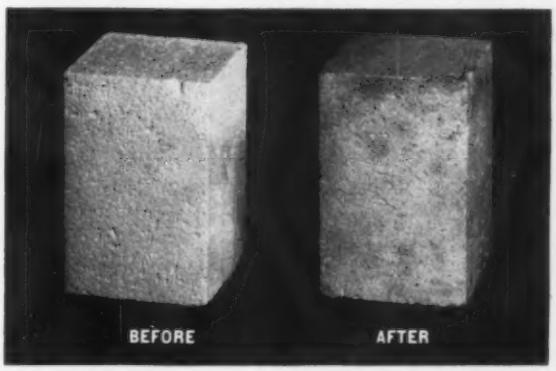
Harbison-Walker H-W 23 LI insulating fire brick produced primarily for controlled atmosphere furnace requirements is of exceptional purity. In addition to greatly enhanced resistance to the detrimental action of gases such as CO, H, CH_4 and others, its desirable physical properties of strength, low permeability and good volume stability, adapt this brand also to a wide variety of other uses with important benefits.

Very low bulk density (30 to 32 pcf), augmented by minute pore size, accounts for its high insulating value. Exceedingly fine texture contributes to desirable glazing and to its good resistance to penetration by volatile fluxes.

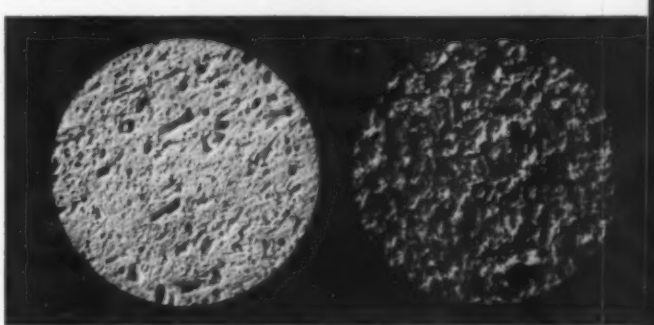
In the prescribed A.S.T.M. 210-46 test for 2300°F. insulating fire brick, the H-W 23 LI brand, when held at the maximum temperature for 24 hours, shows zero linear change.

The crushing and transverse strengths of H-W 23 LI are adequate for sustaining its weight and the thrust imposed in arches of relatively wide spans, up to its temperature limit.

The optimum combination of physical and chemical properties of H-W 23 LI insulating fire brick accounts for preeminence in its class. Write for complete specific information. A sample will illustrate its excellent workmanship.



H-W 23 LI before and after a 500-hour test in an atmosphere of 95% + carbon monoxide (per A.S.T.M.: C288-56), illustrating the high degree of immunity to disintegration by carbon deposition. In this test of long duration at the most critical temperature, H-W 23 LI was unaffected.



Magnification x2, illustrating pore size of H-W 23 LI.

Magnification x2 of another 2300°F insulating fire brick.

Harbison-Walker insulating products also include all conventional classes for service up to 3000°F.

Modern packaging in sturdy cartons assures safe transportation and efficient handling. Packed 25 to a carton.

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World's Most Complete Refractories Service

HW 60-6

Circle 1562 on Page 48-B

Chace
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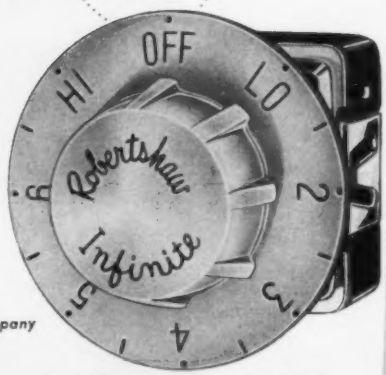
ACTUATES ANOTHER PRECISION PRODUCT...

Robertshaw
MR. CONTROLS

Electric Infinite Control



A product of
Robertshaw-Fulton Controls Company
Indiana, Pennsylvania

Range manufacturers wax enthusiastic over this new development from Robertshaw. And well they might, because this is one Infinite Control designed with the manufacturer in mind! For instance: the new model INF (pictured) is approximately the same size as an ordinary five-heat rotary switch, making it fully interchangeable at any time in the production cycle. The range builder needs to stock only one type control for all elements.

The Robertshaw Electric Infinite Control model INF turns clockwise or counterclockwise and is equipped with three indexing positions: "Off," "High," and "Low." In the "High" position, the control is energized continuously. At other settings it delivers the selected input level under the control of a bimetal timer. A second bimetal is employed as an ambient temperature compensator to neutralize the effect of ambient temperature changes on the control bimetal. *Both* of these important components are made of Chace Thermostatic Bimetal.

By specifying the inclusion of Chace Thermostatic Bimetals in "the most advanced concepts in electric controls," Robertshaw joins many manufacturers who know they can depend on Chace. This dependability is born of more than 30 years of manufacturing only one product: precision bimetal. Any manufacturer can be sure his name is safe on the outside with Chace Thermostatic Bimetal on the inside of his product.

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If your new product is approaching the design stage, send for "Information Booklet". It contains design data, illustrations and applications for more than 30 types of Chace Thermostatic Bimetal. Chace bimetal is available in stripes, coils and in completely fabricated elements of your design.

IT BENDS WITH THE HEAT

W. M. CHACE CO.
Thermostatic Bimetal
1926 BEARD AVE., DETROIT 9, MICH.

Circle 1563 on Page 48-B

Cylindrical Texture . . .

In this work, a synthetic cylindrical texture was first produced by forming a rolled sheet into a cylinder and maintaining the rolling direction parallel to the axis of the cylinder. The Debye-Sherrer method was used throughout the work, and the patterns obtained on various specimens were compared visually with that of the synthetic cylindrical texture.

The diffraction rings obtained from a wire having a normal fiber texture will show localized areas having enhanced intensity which are related to the preferred crystallographic directions within the wire. For the <110> fiber texture, peaks occur at approximately 60° and 90° to the wire axis on the rings caused by the (110) planes and at 45° and 90° to the wire axis on the (200) rings. The cylindrical texture imposes a restriction on the orientations available for diffraction and the (110) 90° and (200) 45° peaks are eliminated. This was, in fact, shown in the synthetic cylindrical texture and in the drawn wires.

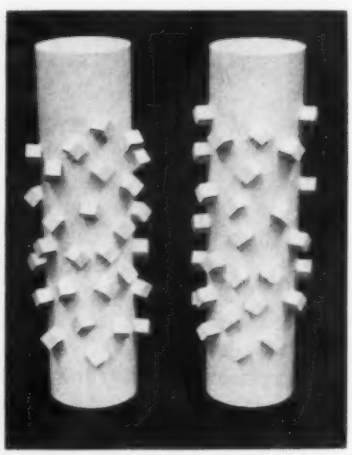

Fig. 1 — Models Showing Fiber Texture (Left) and Cylindrical Texture (Right)

Samples of tungsten, molybdenum, iron and columbium were selected from random ingots at every die size for study. At selected sizes, the variation in texture across the radius was also studied by etching the wire to ¾, ½ and ¼ of its original diameter prior to examination by diffraction.

As the degree of deformation in-

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Sandvik spends extra time, money and effort to produce spring steels with the quality to meet difficult performance demands.

From the ore in Sandvik's mines to the finished strip, Sandvik applies constant, rigid quality control to every steel-making step. Special analyses, careful, small-lot processing, modern laboratories equipped with special scientific instruments . . . these are behind Sandvik's record of success in tough spring steel applications.

For special physical properties plus accurate and uniform flatness, straightness, width, gauge and edge finish, specify Sandvik. Wide variety of qualities and sizes in stock plus local Sandvik facilities for custom-processing and finishing to your requirements. Send for free brochure.

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Circle 1564 on Page 48-B

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- Electrically operated working bridge plus air operated grips for easy inspection or removal of specimens.
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Testing and Balancing Machines

Circle 1565 on Page 48-B

Cylindrical Texture . . .

creased, an increased tendency for axial alignment of the crystals was observed. This same trend was observed from the surface towards the center of the specimens. This variation in range of inclination of the <110> directions to the wire axis with diameter and radial position was quantitatively determined, and the variation of rotational alignment of the crystals was also measured.

Rotational misalignment increased from surface to center of the wire. The relationship between the intensities of the peaks could be used to estimate the occurrence of maximum rotational randomness since an increase in deformation would produce no further change in relative intensity. It was assumed that the fiber structure is normal at that stage.

Since both axial alignment and rotational misalignment increase with increasing amounts of deformation, and since the same trend is observed from surface to center of the wire, the implication is that the degree of deformation increases from the surface to the center of the wires. This conclusion was corroborated by metallographic examination which showed that deformed grains appeared initially in the center of the wires and that this region recrystallized most rapidly during annealing.

Intermediate recrystallization treatments during the wiredrawing impeded the conversion of the cylindrical to the fiber texture, indicating that the orientation is randomized by the recrystallization treatment. Another interesting observation was that deformations in excess of 95% caused a progressive increase in recrystallization temperature which is possibly due to the change in deformation texture.

Similar results were obtained for molybdenum, iron and columbium wires. In particular, a very definite cylindrical texture was produced at the surface of the iron while an almost completely fibrous texture was disclosed at one-half the original diameter.

All results obtained indicate that a cylindrical texture can be expected to form as an intermediate texture during the fabrication of wires from body-centered cubic metals. This texture is a normal result of the radial compressive stresses imposed by the

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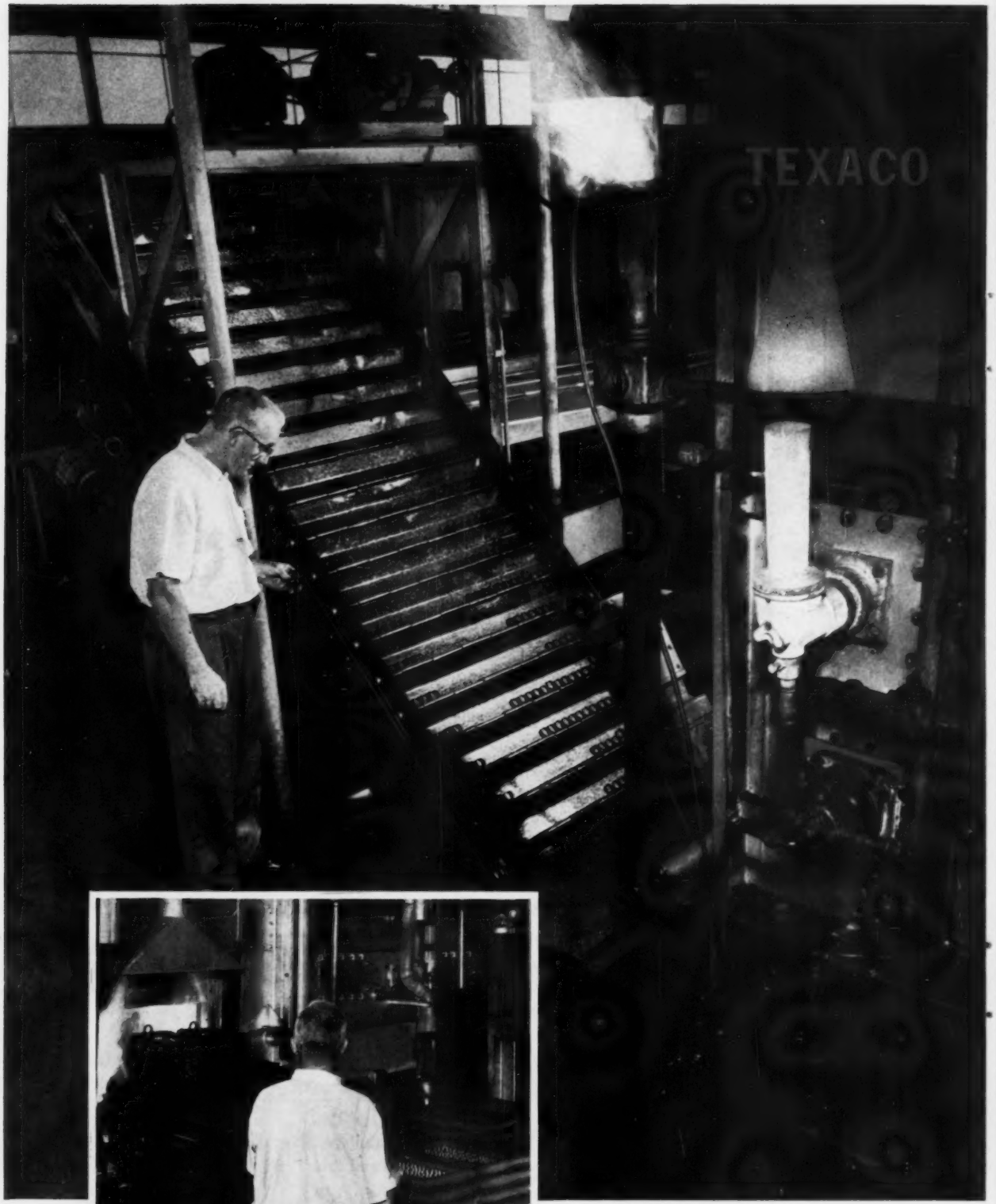
38 Years of Service to Industry

Circle 1566 on Page 48-B



Photos taken at Hoover Ball and Bearing Company, Ann Arbor, Mich., show (left) parts going into heat treat furnace and (above) coming out of Quenchtex bath.

QUENCHTEX OILS GIVE UNIFORM HARDENING IN THE PIECE

with improved grain structure... no darkening of metal...longer bath life...

The proper choice of a quenching oil depends on the analysis of the steel being used and the hardness desired, among other factors.

A properly chosen quench for any given steel should remove heat fast in the high temperature range, and at a lower rate as the temperature drops through the low ranges where the metal becomes brittle and subject to stress. Because steels vary widely in analysis, Texaco offers three separate QUENCHTEX OILS—each with a different cooling curve.

The differences in cooling rate between the three QUENCHTEX OILS are functions of their composition:

- **QUENCHTEX 500**—a conventional or straight mineral oil of low viscosity;
- **QUENCHTEX 510**—a medium-speed oil blended with special additives;
- **QUENCHTEX 520**—a high-speed oil blended from refined paraffin base crudes plus additives.

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- Stability at recommended temperatures
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- **Compatibility with other quenching oils. You can begin using Quenchtex now—regardless of the oil now in your tanks.**

A Texaco Metalworking Specialist will be glad to take a sample of the oil you are now using for testing by Texaco's Research Laboratory. A cooling curve will be run on the sample and the compatible QUENCHTEX OIL will be recommended for make-up. For further information contact the nearest of the more than 2,300 Texaco Distributing Plants or write:

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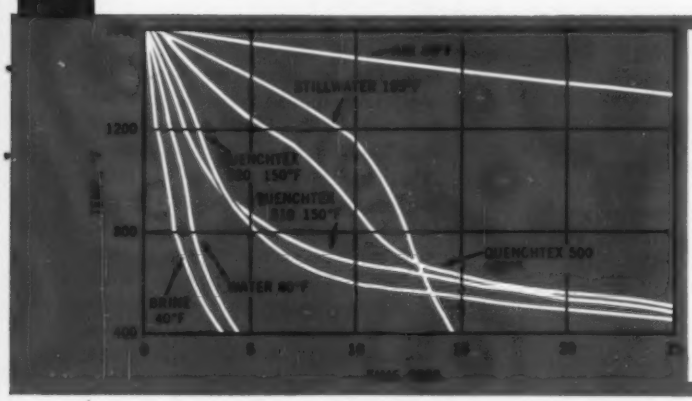

Chart shows cooling rates of several quenching media including QUENCHTEX 500, 510 and 520.

TEXACO MARQUENCH FOR HOT OIL QUENCHING

For products where full hardness combined with minimum distortion is required—gears, ball and roller bearings, bearing races, etc.—hot oil quenching with MARQUENCH can help reduce the number of rejects, increase product load capacities, and in some cases permit closer tolerances before quenching.

TEXACO

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Canada • Latin America • West Africa

Circle 1567 on Page 48-E

Want to strip "unstrippable" coating?

ask Oakite

OVER 50 YEARS CLEANING EXPERIENCE • OVER 250 SERVICE MEN • OVER 160 MATERIALS

Even tough EPOXY FINISHES peel off in Oakite STRIPPER S-A

Burn off an epoxy finish from a reject as a last resort? Not at all necessary. Oakite STRIPPER S-A strips metals clean. That's true for multiple coats as well as single coat epoxy finishes. Look at STRIPPER S-A's record:

- *A 3/16" thick coating built up from layers of epoxy coating and wrappings of fiber glass was stripped from gun barrels by overnight soak in Stripper S-A. Everything tried previously had failed.*
- *Brass plated steel parts were stripped of their epoxy finish in matter of minutes.*
- *Workholding spindles and racks laden with at least 10 coats were stripped to bare metal by a short soak. Paint hooks formerly burned clean are now soaked clean instead.*

This powerful stripper is safe for all metals except zinc and magnesium. And it's safe to the user, since it works cold . . . has no flash point . . . rinses with water.

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Circle 1568 on Page 48-B

Cylindrical Texture . . .

die; it indicates that these stresses cannot be ignored in studies of the mechanism of deformation during drawing, extrusion swaging, and other forming processes.

Although the concept of the initial formation of a (100) [110] cylindrical texture has been proven correct, no mechanism has been found yet to account for the conversion of the cylindrical texture into a fiber structure. H. P. TARDIF

Salt Corrodes 18-8 Stainless Steels

Digest of "Rapid Intergranular Oxidation of 18-8 Stainless Steels by Oxygen and Dry Sodium Chloride at Elevated Temperature", by H. W. Pickering, F. H. Beck and M. G. Fontana. ⊖ Preprint No. 232, 1960

THE AUTHORS REPORT experimental data on the corrosion of stainless steels (and a titanium alloy) exposed to air and dry sodium chloride in the 200 to 1400° F. range.

Four grades of stainless steel were used: Types 304 ELC, 304 347 and 430. Specimens were cut from sheet, polished, annealed at 1800° F. (or 2000° F.) for 1 hr., furnace cooled, and pickled. Next specimens were dipped in a saturated salt solution to apply a salt coating about 0.06 in. thick. After drying, the salt-coated specimens were heated in an air furnace for various times, the majority of the tests being for 13 hr.

Between 200 and 1100° F., the austenitic stainless steels suffered moderate surface oxidation, but between 1100 and 1600° F., the attack became intergranular in nature. Though Type 430 showed more surface oxidation between 1100 and 1400° F. than the austenitic steels, intergranular corrosion was absent.

To observe the effect of stress on this intergranular corrosion, tensile specimens were tested at applied stresses up to the yield point. The results indicated that stress had no effect on surface corrosion and only a minor influence on intergranular attack. (A subsidiary experiment with 6 Al, 4 V titanium alloy stressed to 50,000 psi. confirmed the results of previous work that titanium is

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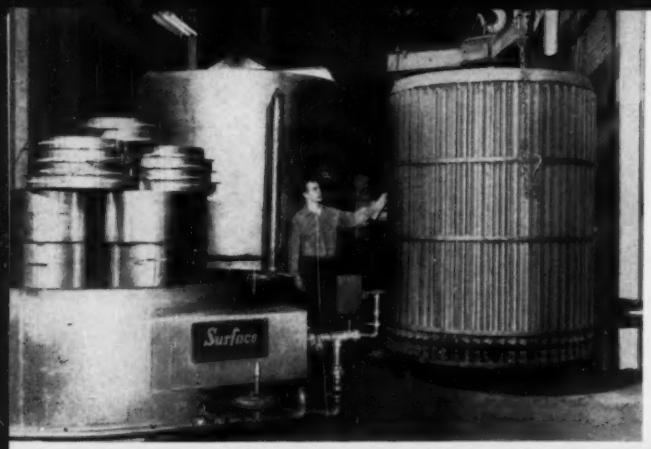
Circle 1569 on Page 48-B



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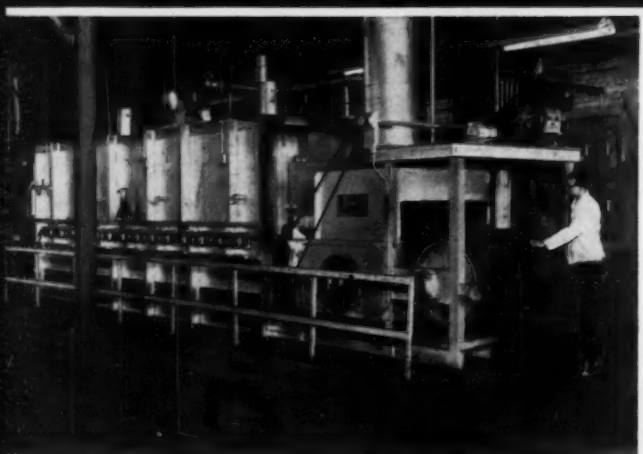
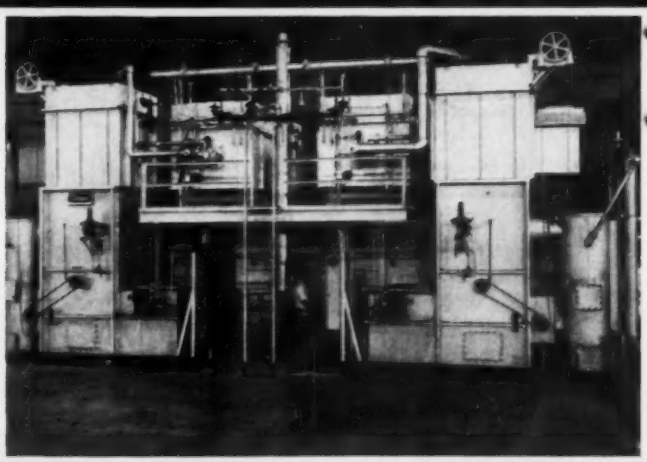
Aluminum coils

Steel gears and pinions

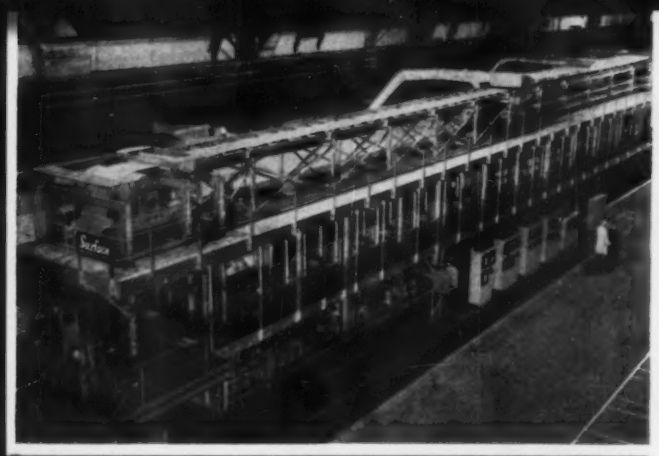
Aluminum billets



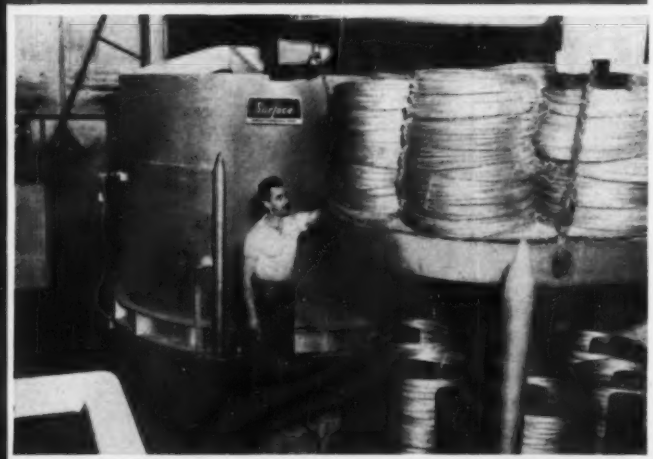
Automotive steel forgings



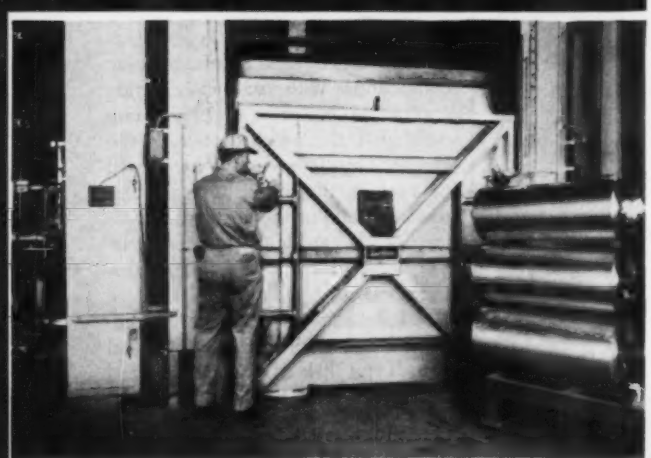
Brass tubing



Steel strip



Brass wire



Aluminum foil

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Rates of heat transfer by radiation are limited by maximum available "thermal heads," various shapes and heat absorption properties of work pieces, and control problems which become critical when rate of heat transfer is very high.

On the other hand, heat transfer by convection can take place at rates of extreme speed, with air temperature very close to the desired work piece temperature, assuming very high air velocities.

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So effective are Surface's new techniques in convective heat transfer, that we can now define a furnace in terms of its **convection power:** its ability to heat the work primarily by convection, with great speed, uniformity, and efficiency.

Some of the results are spectacular; all have brought about important cost savings or product improvement. We invite you to write for Bulletin SC-182 describing Surface Power Convection equipment in more detail. Surface Combustion, 2377 Dorr Street, Toledo 1, Ohio. In Canada: Surface Industrial Furnaces, Ltd., Toronto, Ont.

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Circle 1570 on Page 46-B

High Carbon Steel

wears almost III times longer when

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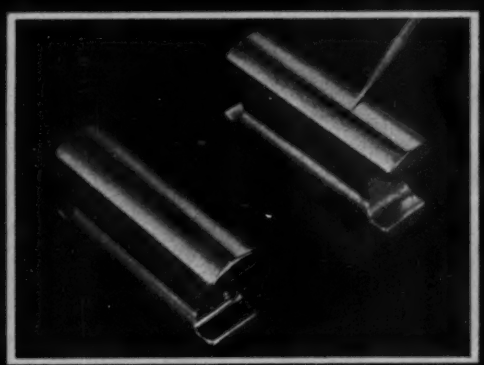
In a test conducted by the Formsprag Company of Warren, Michigan, CHROMALLIZED sprags were removed from an automobile transmission after 55,000 miles of use and compared with ordinary sprags from another transmission after 33,000 miles of use. The CHROMALLIZED sprags showed less than half the wear of the other sprags.



Chromallized sprag (left) shows almost no wear, while an ordinary sprag shows considerable wear.

WHAT IS CHROMALLIZING?

A proven process of diffusing Chromium with other elements into the surface provides an alloy case which is integral with the base metal. It can't peel or flake; the chromium and other elements diffuse uniformly into recesses, pores, cracks and even blind holes. CHROMALLIZING provides not only resistance to wear but also considerable resistance to corrosion and oxidation.

This process may be applied to superalloys and refractory metals for high temperature oxidation resistance.

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Circle 1571 on Page 48-S

18-8 Stainless . . .

susceptible to stress-corrosion cracking under these conditions*.)

Specimens of the austenitic steels were also tested at 1300° F., sodium bromide and sodium fluoride being employed for the corroding agents. Both salts promoted rapid intergranular corrosion, but sodium fluoride caused more surface attack than sodium chloride or sodium bromide.

With these data available, the writers postulated a mechanism of attack based on the formation of a nonprotective scale containing

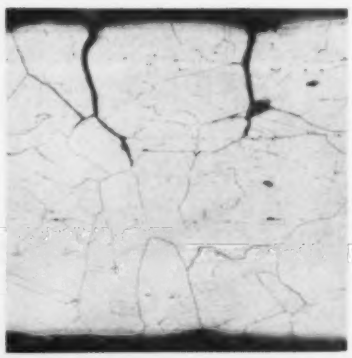
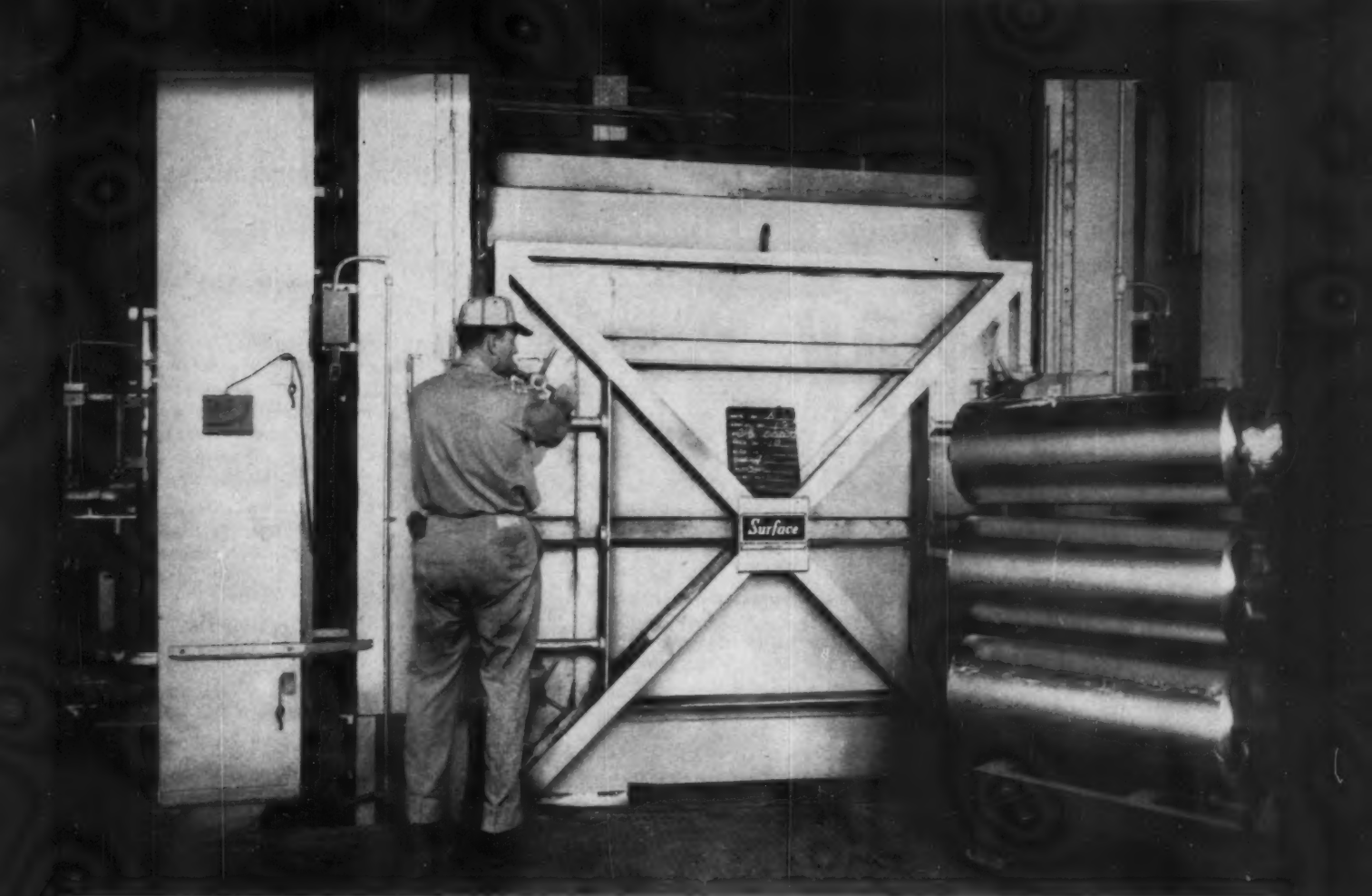


Fig. 1 – Cross Section Showing Intergranular Penetration. Specimen is Type 304 L stainless coated with NaCl, then tested at 1300° F. and 4500 psi. Electrolytic etch, 10% oxalic acid. 35 ×

sodium chromate. According to them, sodium chromate is formed by the reaction of sodium chloride and oxygen with one of the following: chromium oxide (Cr_2O_3), chromium, or chromium carbide ($Cr_{23}C_6$). Subsidiary experiments on the relative reaction rates of these compounds with sodium chloride and oxygen indicated that chromium carbide is the most reactive of the three. This high reactivity was used to explain the rapid intergranular disintegration of the austenitic stainless steels at high temperatures. Further confirmation of this mechanism was seen in the fact that Type 304 stainless with 0.08% carbon appeared to be more severely attacked than Type 304 ELC and stabilized Type 347. B. E. HOPKINSON

*"Progress Report on the Salt Corrosion of Titanium Alloys at Elevated Temperatures and Stress", TML Report No. 88, 1957, Battelle Memorial Institute.



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Power Convection* equipment simplifies furnace construction,—just one fan, minimum furnace size for its capacity. This reduces both first cost and operating maintenance. For more data on Surface Power Convection equipment write for Bulletin SC-182. Surface Combustion, 2377 Dorr Street, Toledo 1, Ohio. In Canada: Surface Industrial Furnaces Ltd., Toronto, Ontario.

*Trademark of Surface Combustion, Division of Midland-Ross Corp.

Circle 1615 on Page 48-B

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H60-3. This advertisement appears in Iron Age; Steel; Metal Progress; Industrial Heating.

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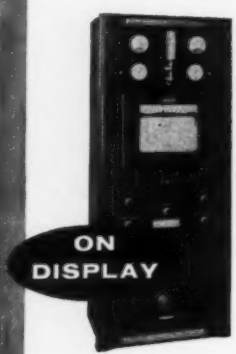

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- Accurately controls carbon potential of furnace atmospheres (not by dewpoint).
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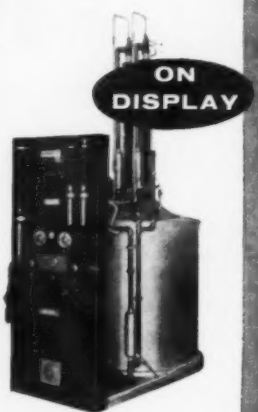

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Circle 1616 on Page 48-B

Yttrium-Titanium Alloys

Digest of "Phase Equilibria and Properties of Yttrium-Titanium Alloys", by D. W. Bare and O. N. Carlson. Preprint No. 178, 1960.

THIS SYSTEM IS of interest because of the possible use of titanium-clad yttrium as a reactor component. The yttrium used, prepared by calcium reduction of yttrium trifluoride, was of 99+ purity, major impurities being oxygen and titanium. Both crystal bar and grade-A titanium were used. Alloys were prepared by melting titanium and yttrium in an arc furnace under a helium atmosphere. Microscopic, thermal analysis and resistometric techniques were employed in examining these alloys.

Solidus temperatures were determined by sighting with an optical pyrometer on a small hole drilled in an electrically heated bar specimen.

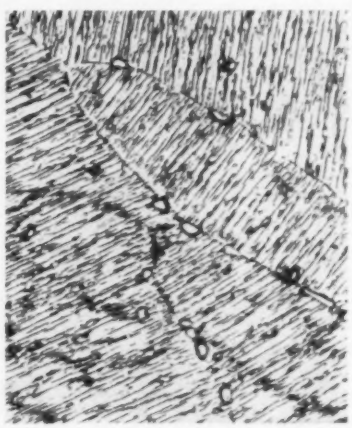

Fig. 1 — Yttrium Alloy Containing 1.5% Ti Quenched From 1300° C. Agglomerations of titanium (clear areas) can be seen along the boundaries of the yttrium grains. Unetched, 250 ×

Using this method, two horizontals were detected, one at 1330° C. and the other at 1480° C. The 1330° C. horizontal is the result of a eutectic reaction, the eutectic having a composition of 13 wt.% titanium. The 1480° C. horizontal is postulated to be the result of a peritectic reaction at 0.2 wt.% titanium. Maximum terminal solubility at the titanium end of the system is placed between 0.6 and 1.3% yttrium and at the yttrium end, less than 1% titanium.

Liquidus points were obtained by

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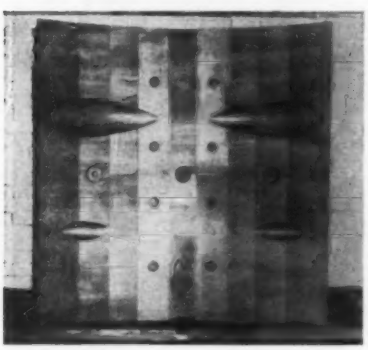

Photo shows inner wall of an 11 foot long graphite thermal column. Graphite was chosen for this installation because it is an excellent moderator of neutrons with low capture cross section.

This wall has 30 major blocks; the other 4 walls have 144 accurately machined blocks each. In all, 1300 precision machined graphite pieces are included in this thermal column. Close tolerances were held in machining each piece.

Many Universities are now using Graphite Moderated Training Reactors

Dr. E. F. Leonard, director of Laboratory Work for Columbia University, inserting a neutron source of plutonium-beryllium obtained from the Atomic Energy Commission.

A recently conducted survey shows that many universities throughout the country are using graphite exponential piles for training the sorely needed nuclear engineers of tomorrow. The survey also points out some of the advantages associated with graphite which are not found in other types of subcritical piles.

Graphite offers longer neutron diffusion (approximately 50 cm) and permits wider fuel rod spacing to assure accurate flux measurements. Also flux distortions are easily determined in graphite piles.

The structural and machineability features of graphite permit students to design and construct the pile. There are abundant experimental data and procedure history available on graphite (it's the oldest type of subcritical reactor) which permit more time for advanced experiments rather than basic fundamental experimentation.

A graphite pile also offers considerable flexibility. It is easy to change configuration, to introduce voids, to accurately position samples, and the pile can be operated as either a bare or reflected system.

Dr. T. J. Thompson, professor of Nuclear Engineering at M.I.T., removing a plutonium-beryllium neutron source from the subcritical nuclear reactor.

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NATIONAL CARBON COMPANY

UNION CARBIDE

Y-Ti Alloys . . .

analyzing samples which had been removed from a molten alloy in thermal equilibrium with either solid yttrium or titanium. Alloy of eutectic composition was placed in both titanium and yttrium crucibles, and heated in a graphite resistor furnace to the desired temperatures. Equilibrium was attained by stirring with a tantalum agitator, then a sample was analyzed and the results plotted against the temperature at which the sample was taken.

Alpha-beta transformation studies at the titanium end of the system indicated that addition of yttrium lowered the transformation temperature of sponge titanium about 8° C. There was no evidence of a eutectoid reaction, and it is postulated that yttrium removed oxygen from the titanium, thus lowering the transformation temperature.

Hardness tests showed that additions of titanium to yttrium markedly increased hardness, while additions of yttrium to titanium lowered the hardness. Oxidation tests were conducted in air at 500° C., and corrosion tests were made in boiling distilled water. Oxidation and corrosion rates were low at the yttrium end of the system increasing to maximum at the eutectic composion.

W. R. Opie

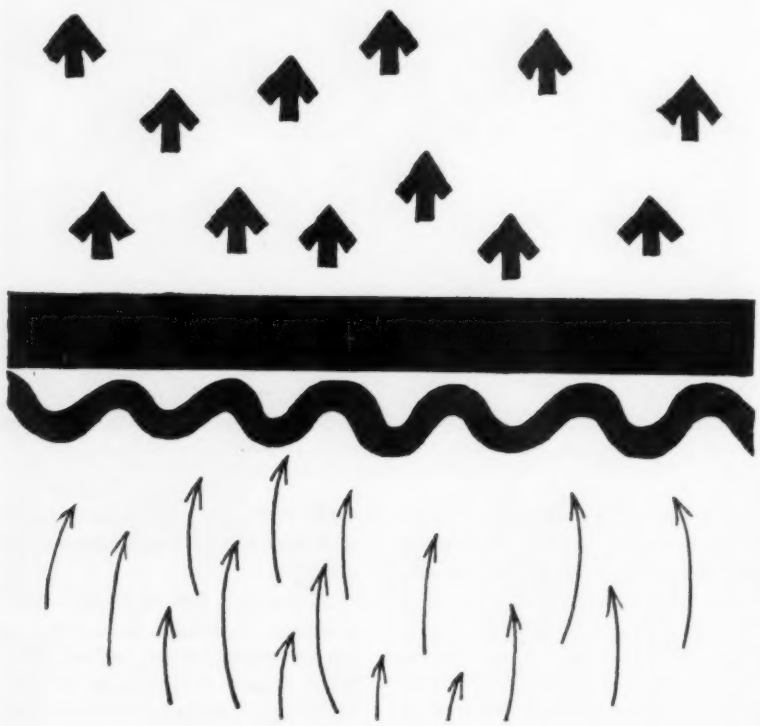
The Cd-Bi-In System

Digest of "The Ternary System Cadmium-Bismuth-Indium", by E. A. Peretti. Preprint No. 184, 1960.

Through the use of thermal analysis, along with microscopic and X-ray data, the complete ternary system was investigated. Experimental alloys were first made from bismuth and cadmium, 99.99% pure, and indium, 99.97%. The alloys were melted in pyrex crucibles under mineral oil, and were mechanically agitated. Liquidus determinations were made with an accuracy of ±2° C.

Fig. 1 – Alloy Containing 30% Cd, 49% Bi, and 21% In, Air Cooled. Primary cadmium plus bismuth, gamma and cadmium. Etchant, ferric chloride; 500 ×

Cadmium, being the component with the highest melting point, dominated about 75% of the diagram. There are five different areas of pri-



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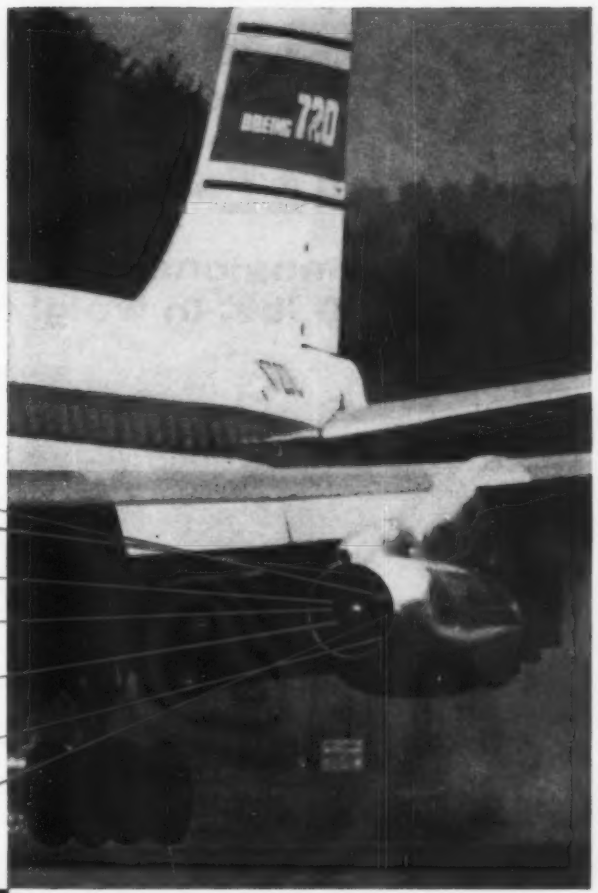
Circle 1618 on Page 49-S



at the touchdown
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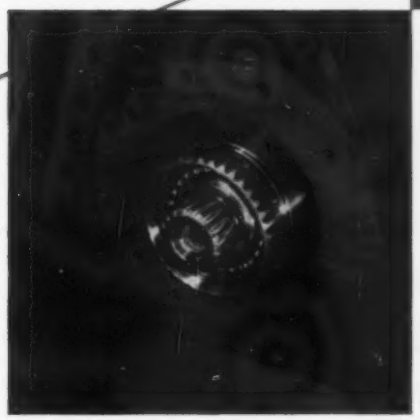
VAC-ARC®
steel goes to work



Thrust reverser bearing assemblies, made of Latrobe's Vac-Arc BG 41 Stainless, take compressive stresses of more than 600,000 psi and temperatures in excess of 800°F. as new Boeing 720 jetliner brakes to a stop. Bearings by Torrington Co.; Thrust Reversers by Rohr Aircraft; Jet Engines by Pratt & Whitney Aircraft.

VAC-ARC BG 41 "hot hardness" withstands critical braking action of new Boeing 720

Through the use of thrust reversers and wheel brakes, the new Boeing 720 has been brought to a full stop within 2200 feet after runway touchdown—bringing high speed jet service to restricted runway facilities throughout the world.

The thrust reverser bearing assemblies, made of Latrobe's new Vac-Arc BG 41 Stainless (modified Type 440 C), withstand the critical stresses at elevated temperatures imposed by the braking action of reversing the jet engine thrust.

Here's another example of Latrobe Metalmasters meeting the challenge for super steels in the jet and missile age. Vac-Arc Steels (consumable electrode vacuum melted) continue to set new standards for cleanliness, homogeneity and high strength.

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Circle 1619 on Page 48-B

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What are *your* requirements for corrosion, abrasion, or mechanical service? Talk it over with your Ampco field engineer. Write for bulletin.

6-210

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Circle 1620 on Page 48-S

Cd-Bi-In System . . .

mary crystallization having bismuth, cadmium, alpha (indium-rich), beta (In_2Bi), and gamma (InBi) as the primary phases. No ternary compounds were found. The InBi-Cd joint is a quasi-binary containing a eutectic which melts at 86.5° C. and contains 12% cadmium. However, the In_2Bi-Cd joint is not a quasi-binary because In_2Bi melts incongruently.

In the high-bismuth portion of the diagram, a bismuth-cadmium eutectic valley meets a bismuth-gamma eutectic trough at a reaction point (93.5° C. with a composition 62.5% Bi, 9.4% Cd and 28.1% In). The resulting valley falls to a ternary eutectic (Cd-gamma-beta) at 77.5° C. (10% Cd, 48.5% Bi and 41.5% In). A second ternary eutectic (Cd-beta-alpha) occurs at 7.5% Cd, 30.83% Bi and 61.77% In (61.5° C.).

W. R. Opie

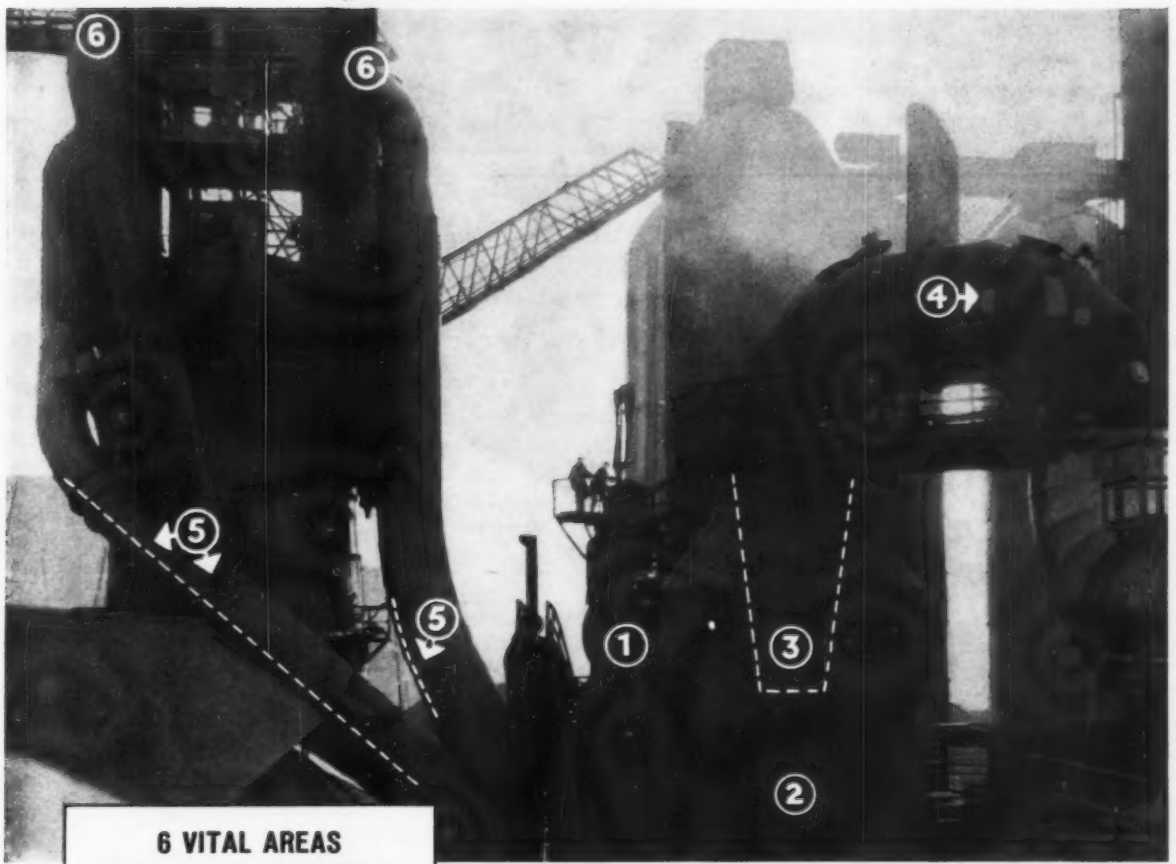
Cast Iron Solidification

Digest of "Gray and White Solidification of Cast Iron", by Mats Hillert. Preprint No. 216, 1960.

The unusual solidification sequence in cast irons showing inverse grayness or inverse chill has recently been explained in terms of variations in cooling rate. These phenomena – the appearance of a gray surface rim in white-iron castings, called inverse grayness, and the appearance of a white core in gray-iron castings, called inverse chill – have attracted some interest due to their practical consenquences. This paper discusses the explanations which have been offered to account for the observed behavior, and presents new experimental work which emphasizes the importance of the high rate of formation of ledeburite once cementite has been nucleated during the cooling of cast iron.

A unique approach has been used to produce and study the thickness of the rim of inverse grayness in relation to the silicon content of the melt. Figure 1 shows the gray rims produced at the outer circumference of a solidified melt and at an inner radius where a quartz tube had been inserted into the melt. The fact

Industrial concretes protect blast furnace "hot spots"



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Circle 1621 on Page 48-B

Cast Iron . . .

that the thickness of the gray rims at the quartz tube and at the other surface of the casting, as well as the radii of some spherical cells of graphite eutectic, were all about the same size indicates that the gray solidification started almost simultaneously at all these locations and later stopped at a certain time. Figure 2 shows how increasing the silicon content changes the rim thickness.

Fig. 1 — Gray Rims Produced Inside a White-Iron Casting at the Sides of a Quartz Crucible. 5 ×

It appears that the initial gray solidification depends on easy nucleation of graphite. The fact that graphite eutectic forms more rapidly than ledeburite at high temperatures but more slowly at low temperatures has direct bearing on the solidification sequence in inverse grayness and inverse chill. In the familiar case of a normal chill, the chill mold, initially cold, lowers the temperature sufficiently to prevent the formation of graphite eutectic.

A more detailed consideration of the formation of graphite and cementite suggests that they are nucleated by a heterogeneous nucleation process. A likelihood exists that there are preferred sites in the melt for nucleation which are not activated until supersaturation with respect to graphite or cementite reaches a high value as the melt is cooled. The first sites to cause nucleation are likely to give rise to graphite since the phase diagram shows that an iron-carbon melt will first become supersaturated with

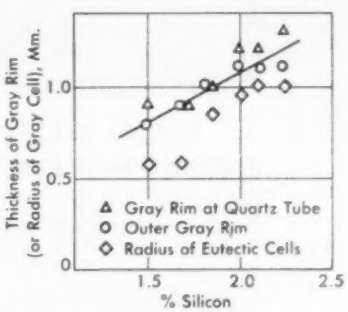

Fig. 2 — Thickness of Graphite Eutectic (Gray Rim) as a Function of Silicon Content

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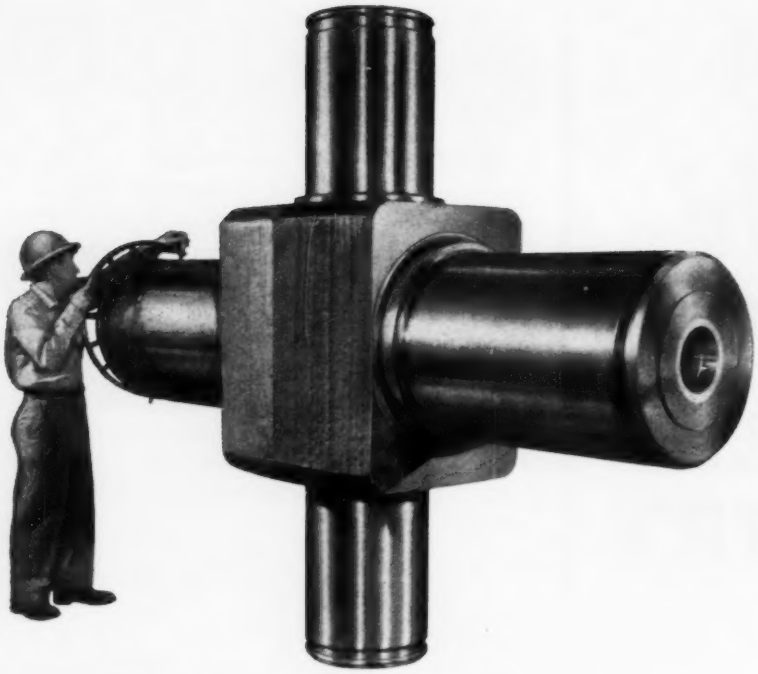

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Circle 1624 on Page 48-B

Cast Iron . . .

graphite when cooled. As cooling continues, the supersaturation is increased. However, the difference in slope of the solubility lines in the phase diagram shows that the supersaturation of cementite increases faster than the supersaturation of graphite. This results in an increasing probability for the nucleation of cementite as the temperature is lowered. Once nucleated, cementite will form ledeburite which dominates over graphite in a wide range of temperatures.

Another factor which promotes the formation of graphite is silicon content. Silicon widens the range of temperature in which graphite eutectic forms more rapidly than ledeburite; completely gray solidification can be expected if the range is made wide enough to include the actual temperature of solidification. Figure 2 suggests that, to obtain a completely gray structure, silicon additions might be raised sufficiently to increase the gray surface rim to cover the whole volume of the casting.

It is concluded that the role of silicon in promoting gray solidification depends mainly on its effect on the nucleation of graphite. Rapid cooling promotes white solidification mainly because cementite is more easily nucleated the lower the temperature. Inverse grayness and inverse chill are related phenomena. In both instances, the change from gray to white solidification takes place when favorable conditions for nucleation of cementite have been established at some locality in the melt. The favorable conditions may be established by a local decrease of temperature or by local segregation of some element, the former factor probably being of primary importance in many instances of inverse chill. After its nucleation, cementite spreads rapidly and dominates the solidification of the remaining melt, even where the conditions for nucleation and growth of cementite have not grown more favorable than during the preceding gray solidification. Especially in inverse grayness, the conditions may even become less favorable, due to the heat evolution from the rapidly growing ledeburite. Yet, the white solidification process will continue.

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Circle 1625 on Page 48-E

Cast Iron . . .

It is possible that the conditions for growth of cementite may finally become so much less favorable that the solidification process may change from white to gray. This occurs in normal chill as the initially cold mold is heated. D. J. MURPHY

Phases in Transition Elements

Digest of "Factors Controlling the Occurrence of Laves Phases and AB_5 Compounds Among Transition Elements", by A. E. Dwight. ⊜ Preprint No. 211, 1960.

THE INTERRELATIONS of atomic size, stacking geometry, and electronic structure in intermetallic compounds of AB_2 and AB_5 composition were studied. (A elements are transition metals to the left of manganese in the periodic table and B elements are transition metals to the right of, and including, the manganese group.) One hundred and thirteen binary systems were investigated for the presence of Laves phases. Alloys were melted on a water cooled hearth of copper with a tungsten electrode, and powder specimens were prepared by hammering in a closed die followed by annealing under vacuum. Compounds were identified by X-ray diffraction data.

Structurally, the relationships between some Laves phases and others may be simple or complex. For example, replacement of four A atoms by B atoms creates a UNi_5 structure from the $MgCu_2$ structure. Formation of the hexagonal $CaCu_5$ structure from the hexagonal $MgZn_2$ type requires replacement of atoms and leveling of rippled 002 and 001 planes. The possible radii for A and B atoms fall in the range for which the ratio R_A/R_B extends from 1.05 to 1.68. The only possible generalization about structure type is that the $MgCu_2$ type structure is favored for R_A/R_B values greater than 1.40. For the 43 Laves phases studied, A elements were found to contract as R_A/R_B increased, while B elements were found to contract as R_A/R_B decreased. The contraction of a B element is dependent primarily upon its position in the periodic table and, secondarily, upon the position of its partner A element. Contractions of A elements are dependent upon similar factors. With the exception of yttrium and cerium compounds, the axial, c/a, ratio decreases smoothly with increasing R_A/R_B.

The selection of crystal structure by a Laves phase is apparently governed by periodic table relationships, but a quantitative correlation with valency numbers is not yet possible. The graph (see Fig. 1) of crystal structure variations in Laves phases shows a qualitative correlation. The transition from $MgCu_2$ to $MgZn_2$

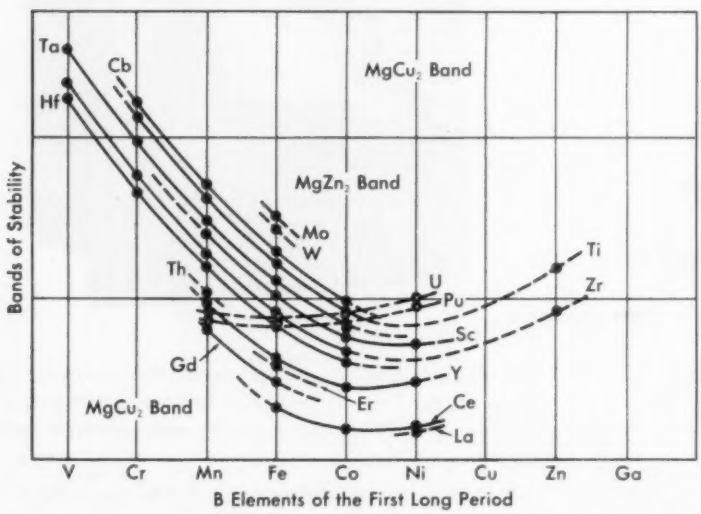

Fig. 1 — Crystal Structure Variations in Laves Phases

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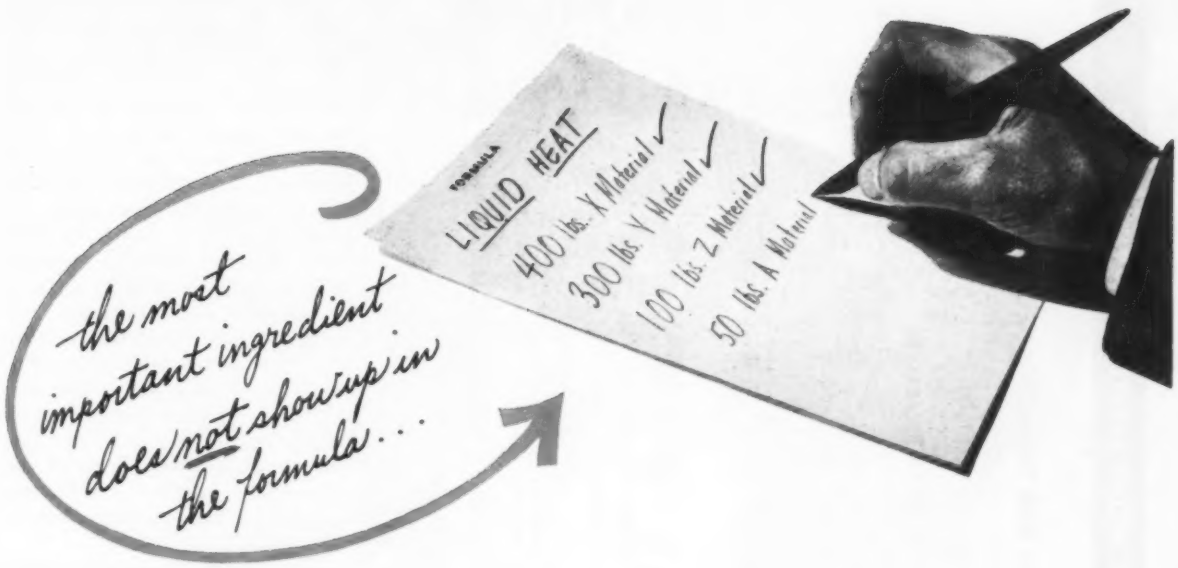
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Circle 1627 on Page 48-S

Transition Elements . . .

to $MgCu_2$ is closely related to the relative positions of the partner elements in the periodic table. That YMn_2, $ZrFe_2$, and $CbCo_2$ all have the $MgCu_2$ structure is implied by the graph, because all have nearly the same electron concentration. The difference between the separated electron levels for most A elements and a "hybridized" electron level for uranium may explain the different shape of the uranium curve in the graph. Because the $MgCu_2$ and $MgZn_2$ structures exist within bands of stability, structural relations can be predicted in some unknown binary, ternary and quaternary systems. Examples are the prediction of the Laves phases to be expected in technicium binaries and the structures of multicomponent Laves phases.

The two most important results of this work are the observations that: (*a*) the ratio of the Goldschmitt radii of the pure elements is not a major factor controlling the formation of a Laves phase, and (*b*) the major factor controlling the formation of Laves phases is the ability of the partner elements to expand or contract so that the ideal axial ratio, 1.225, is approached.

DAVID KRASHES

Determining Hardness by X-Rays

Digest of "The Determination of Hardness in Steels from the Breadth of X-Ray Diffraction Lines", by R. E. Marburger and D. P. Koistinen. ⊖ Preprint No. 228, 1960.

THIS PAPER DESCRIBES an X-ray nondestructive method of measuring the surface hardness of martensitic steels. The method is based on the experimental observation that the breadth of a martensite X-ray diffraction line from the surface increases with increasing hardness. Since the X-ray data needed are those used in determining residual stresses, the two measurements can be made simultaneously.

The method is as follows: Using a counter diffractometer, the intensities at three angular (2θ) positions are measured near the peak of the intensity distribution curve. The

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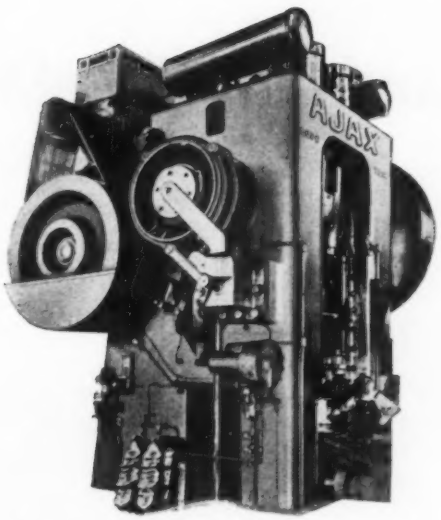

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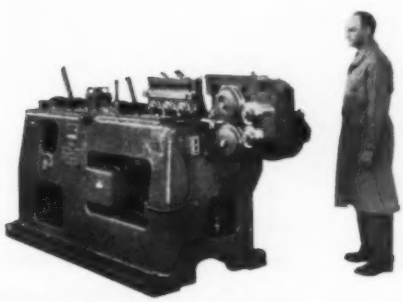

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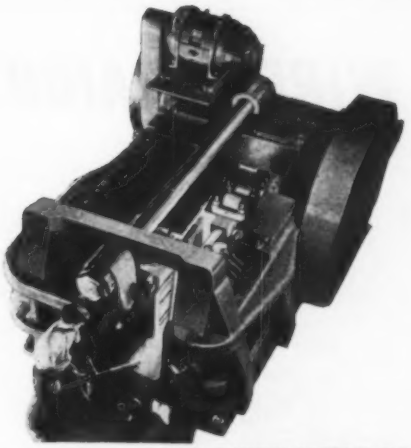

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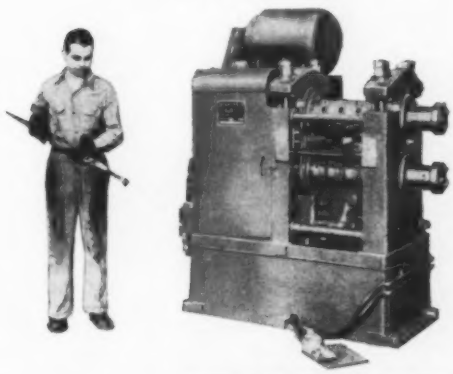

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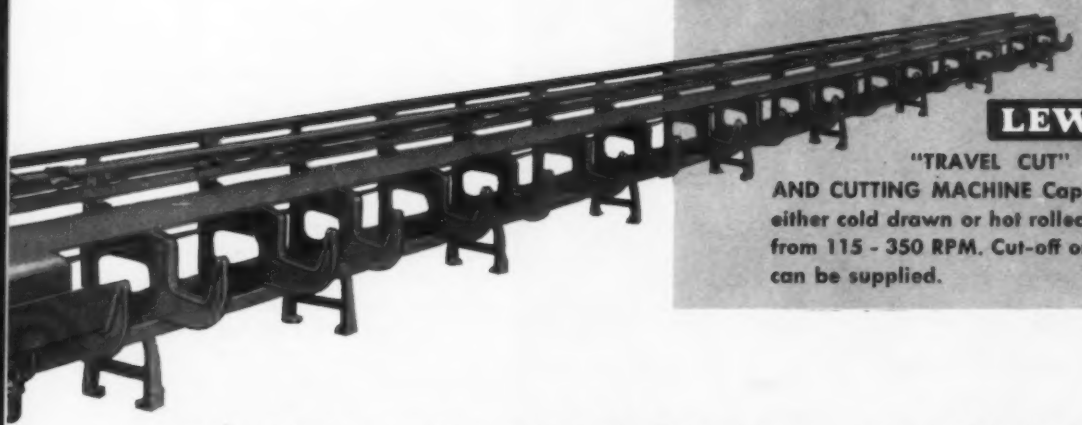

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Circle 1629 on Page 48-B

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Hardness . . .

three points must be spaced at equal angular intervals. (That is, if the first point has a 2θ value of X, the second point is at $X + c$, and the third is at $X_1 + 2c$, where c is an arbitrary angular interval.) Next, a parabola is fitted algebraically to these three points and the half-breadth is calculated, the latter being the breadth at the half-height of the parabola. The calculated half-breadth of such a parabola has been shown to be a reproducibly characteristic index of the half-breadth of the diffraction peak. The expression derived for the half-breadth (denoted $B_{\frac{1}{2}}$) is

$$B_{\frac{1}{2}} = \left[\frac{kc^2}{a+b}\right]^{\frac{1}{2}}$$

where k is the intensity at the axis of the parabola (peak intensity), c the constant arbitrary angular interval as defined above, and a and b the intensity differences between the selected points.

Using a series of tempered martensite S.A.E. 52100 specimens with hardnesses ranging from Rockwell C-29 to 76, the authors derived the following empirical equation correlating hardness with the half-breadth value $B_{\frac{1}{2}}$:

$$\text{Hardness (Rockwell C)} = 39 + 12.9\,B_{\frac{1}{2}}$$

H. H. Chiswik

Microstructure Affects Fatigue Strength of Steel

Digest of "The Effect of Microstructure on the Fatigue Strength of a High-Carbon Steel", by F. Borik and R. D. Chapman. ● Preprint No. 209, 1960.

In a meticulously planned series of comprehensive experiments, which included extreme precautions to minimize the influence of residual surface stresses, it was convincingly demonstrated that the fatigue strength of high-carbon bainite is superior to that of tempered martensite. The results shown in Fig. 1 demonstrate that this is true for a hardness range of about Rockwell C-40 to 61. Below Rockwell C-40, however, the tempered martensite microstructure is slightly stronger. It is also noteworthy that the bainitic curve shows a maximum endur-

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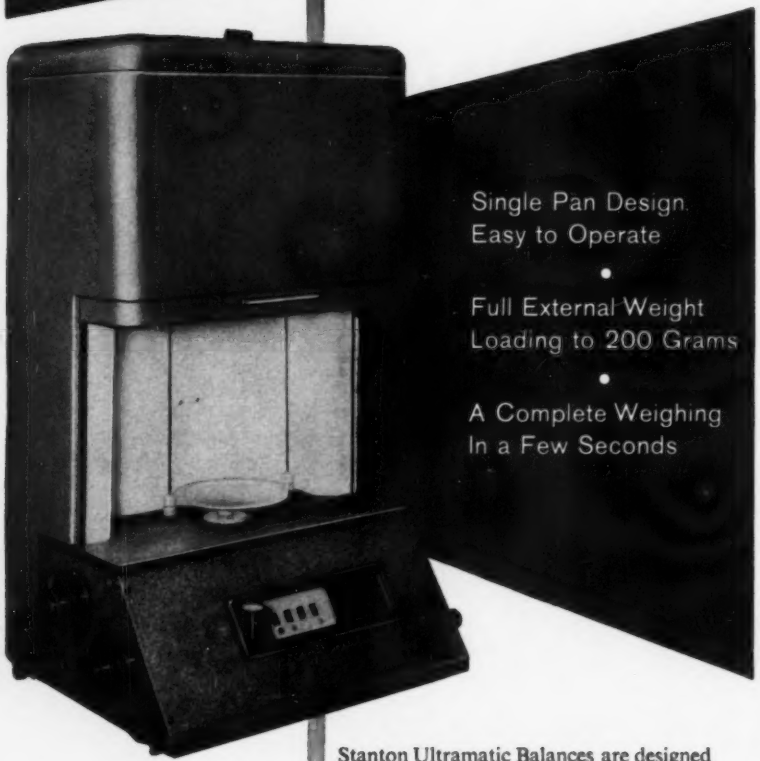

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Circle 1632 on Page 48-B

Fatigue Strength . . .

ance limit at about Rockwell C-57.5 and falls off sharply at higher hardness (although remaining slightly superior to tempered martensite at Rockwell C-61). These observations formed the basis for this work which was planned to determine whether the increased fatigue resistance of such bainite was due to the absence of residual stresses caused by quenching and transformation reactions or due to its more favorable carbide morphology.

For the investigation, S.A.E. 51100 steel was selected because its low M_s temperature allowed the bainite samples to be austempered to high hardness. Also, the so-called "quench-tempering" of the martensitic samples was minimized. The isothermal transformation characteristics of the steel were carefully studied before starting the investigation

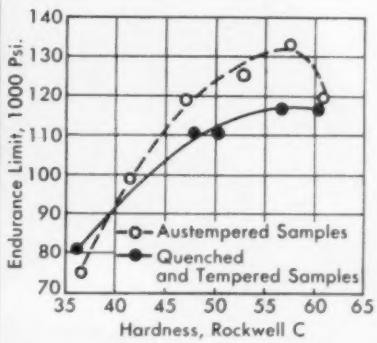

Fig. 1 — Endurance Limit-Hardness Relationship of 51100 Steel With Two Different Microstructures. As can be seen, the bainite structure is stronger above Rockwell C-40

to determine the precise times necessary for completion of the bainitic transformation in the temperature range of interest, 400 to 900° F. following austenitizing at 1800° F.

Representative fatigue samples were checked for residual macrostresses by X-ray diffraction. On the basis of the results obtained, and considering the reproducibility of the method, it was concluded that the extreme care used in sample preparation resulted in the surfaces of the test specimens being virtually free of any influencing residual macrostresses.

Relative microstructures in the matrix of both types of structures

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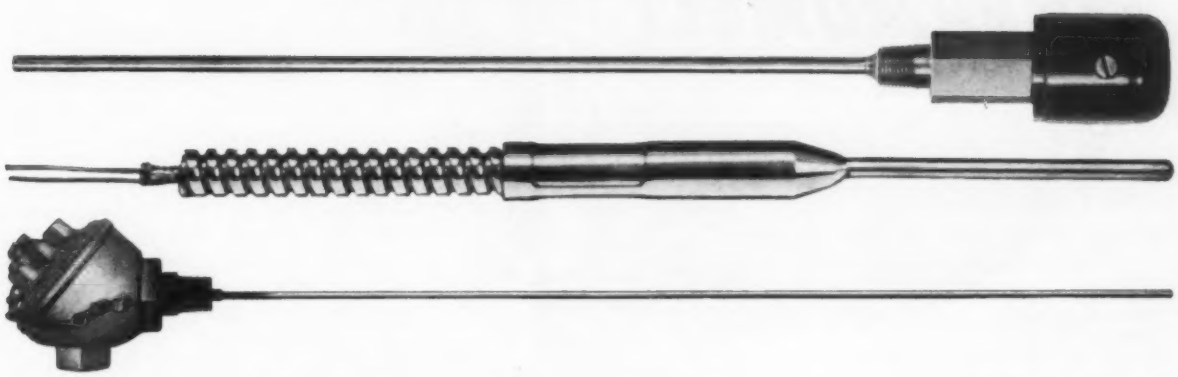

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Circle 1634 on Page 48-B

Fatigue Strength . . .

were evaluated in terms of lattice strains, which were measured by the integral breadth of the (211) iron line X-ray reflections. These strains were found to increase in both microstructures with increasing hardness (as did the endurance limits), and to be higher in the austempered than in the quenched and tempered specimens at all hardnesses up to (but not including) Rockwell C-61.

Since the microstrains are caused by supersaturation of the matrix with carbon, the authors concluded that the increased carbon in solution strengthened the matrix through the mechanism of solution hardening. This made both microstructures more fatigue resistant. The authors further reasoned that, on the basis of the strengthening effect of uncombined carbon, the tempered martensite should have higher fatigue strength than bainite at Rockwell C-61. Similarly, since upper bainite at Rockwell C-36 contains more carbon than tempered martensite of equal hardness, it should display higher fatigue resistance. Since the fatigue tests showed the opposite behavior at these hardnesses, it was concluded that the differences in fatigue strength between the bainitic and tempered martensitic microstructures could not be related to the effect of differences in matrix carbon.

Having thus eliminated both macro and microstresses as pertinent factors, the authors conclude that the difference in the fatigue properties between austempered and quenched and tempered microstructures of this high-carbon steel can be explained entirely by the distribution of carbide particles and their morphology.

Specifically, it is postulated that the higher fatigue strength of bainite above Rockwell C-40 is due to the absence of stress-raising elongated carbides such as those found in tempered martensite. On the other hand, the pearlite mode of the carbides in upper bainite at Rockwell C-36 is less favorable in resisting fatigue than the spheroidized carbides of the tempered martensite at this hardness. These observations are supported by a series of excellent electron micrographs.

G. H. Enzian

Tool Steel Topics

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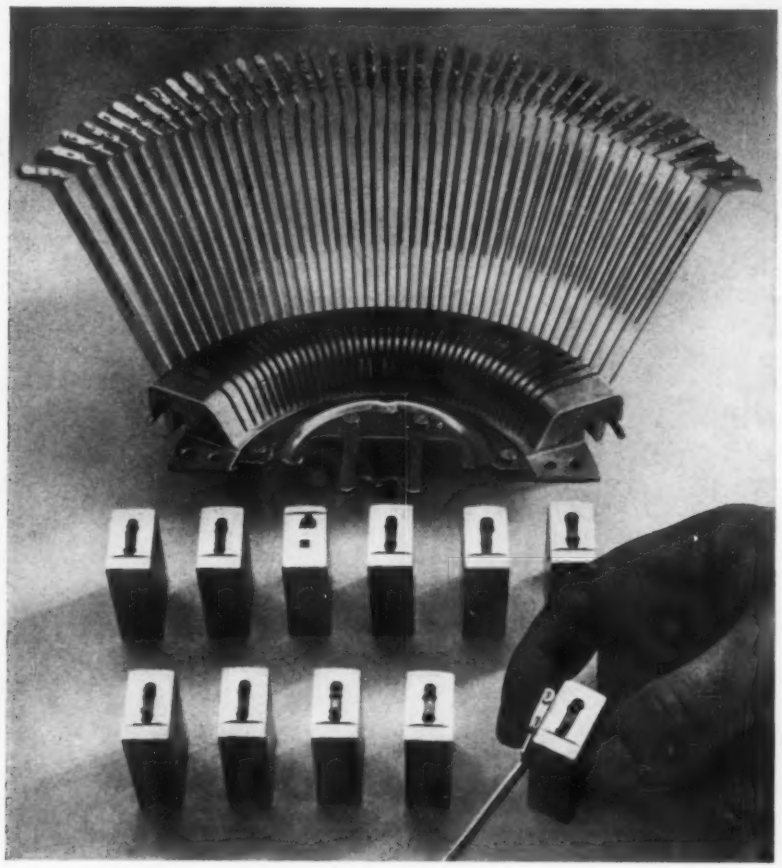

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1. Full-anneal the tools. Good atmosphere control is necessary to avoid scaling and decarburization of the working surfaces.

2. Prepare the crack for welding by "veeing" its full depth and length. Magnetic particle inspection is advisable.

3. Use a welding rod which will deposit steel of the same composition as the tool.

4. Preheat to 400 F - 800 F, and maintain this temperature during welding.

5. Clean the slag from each bead before proceeding with the next bead.

6. Immediately after welding, transfer the tool into a warm furnace (400 F min) and full-anneal.

7. Machine or grind the weld to the desired tool dimensions.

8. Heat-treat the tool by quenching and tempering to the desired hardness, using the standard procedure for the grade involved.

9. Grind the tool working surfaces. The depth of metal removal will depend upon the amount of decarburization produced in Steps 1, 6, and 8.

The use of this procedure will permit the successful welding of tools if it is essential that welding be done. In the majority of instances, however, it will be found both cheaper and quicker to make up new tools.

When emergency welding is done on a production line, it is often necessary to eliminate many of the steps mentioned above, thereby reducing the chances of producing successful welds.

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Circle 1636 on Page 48-B

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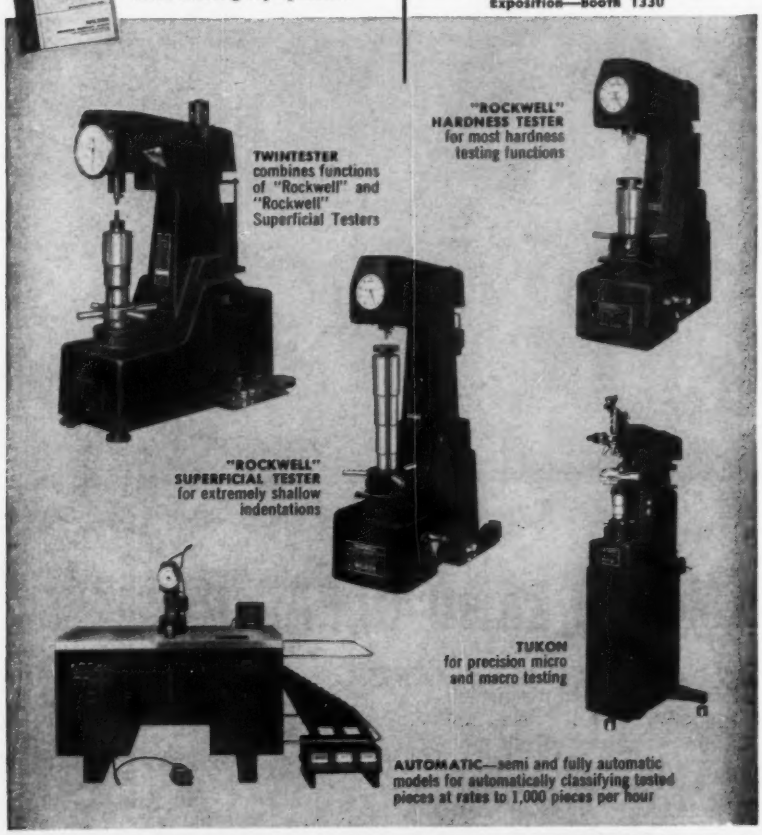
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Circle 1637 on Page 48-S

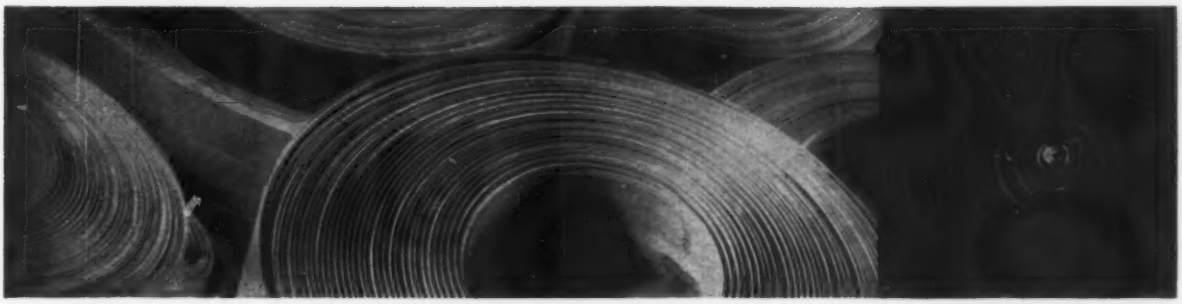
Cold Work and Temperature Affect Steel

Digest of "The Effect of Cold Work and Temperature on Strength and Structure of Steel", by P. Shahinian, M. R. Archer and W. A. Pennington. ⊖ Preprint No. 234, 1960.

ACCORDING TO PUBLISHED INFORMATION, cold work may either improve or reduce the creep-rupture strength of a heat treated low-alloy steel, depending upon the temperature and the degree of deformation. Although data on the role of cold work on elevated-temperature strength of steels are limited and appear to be inconsistent, the inconsistency seems to lie in the determination of the effects of small degrees of deformation. That is, the available evidence indicates that cold deformation in amounts less than about 12% lowers the creep resistance at temperatures below the recrystallization range, whereas higher amounts of prior deformation increase the elevated-temperature strength.

This investigation was undertaken to determine the cause of the anomalous effect of small degrees of cold work on the strength of a low-alloy steel (A.I.S.I. 4140) at elevated temperature. For the most part, the alloy was tested in the quenched and tempered condition, but a few tests were also carried out on material in the annealed condition. Tensile, creep-rupture and hardness tests were conducted to determine the strength and behavior of the steel at the different stages involved in processing of the materials as well as in the final condition. In addition, structural changes in the material were followed by optical and electron microscopy and by X-ray diffraction techniques.

The results of these tests confirmed previous observations that large amounts of deformation improved strength in a normal manner, but small amounts, less than 12%, weakened the quenched and tempered steel at 800° F. It was further established that the lowering of strength at elevated temperature by prior cold work is actually an indirect effect which is dependent on time and temperature in a way characteristic of other thermally activated processes.



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The part shown in illustration one was made from .59 – .74% carbon steel in three drawing stations. From .70 – .80% carbon, this piece should have four or five drawing stations. The piece could be made from .90 – 1.05% carbon, but would require seven drawing stations with fully annealed steel.

2. *Blanked on 45° Angle*

The stamping shown in the second illustration was made from .70 – .80% carbon spring steel. It was blanked and pierced on a 45° angle, with small holes pierced to prevent fracture in later forming and bending. It was then given severe secondary forming. The small tab shows "orange peel" and probable fracture would occur if the part were formed from .90 – 1.05% carbon.

3. *All Flanging One Operation*

Our third part is a gun stamping made from .70 – .80% carbon with a sharp bend with the grain in one stroke of the press. Higher carbon will fracture due to its less ductile qualities.

4. *Thirteen Steps Progressive*

The fastener shown in the fourth illustration was made from the .59 – .74% carbon steel, the only spring steel which would take the bends and draws to which it is subjected here. All the higher carbon steels were rejected because they failed under the cold-work necessary to produce the two small extrusions. It took seven reductions to bring these extrusions within tolerance. There were thirteen steps total in the progressive die.

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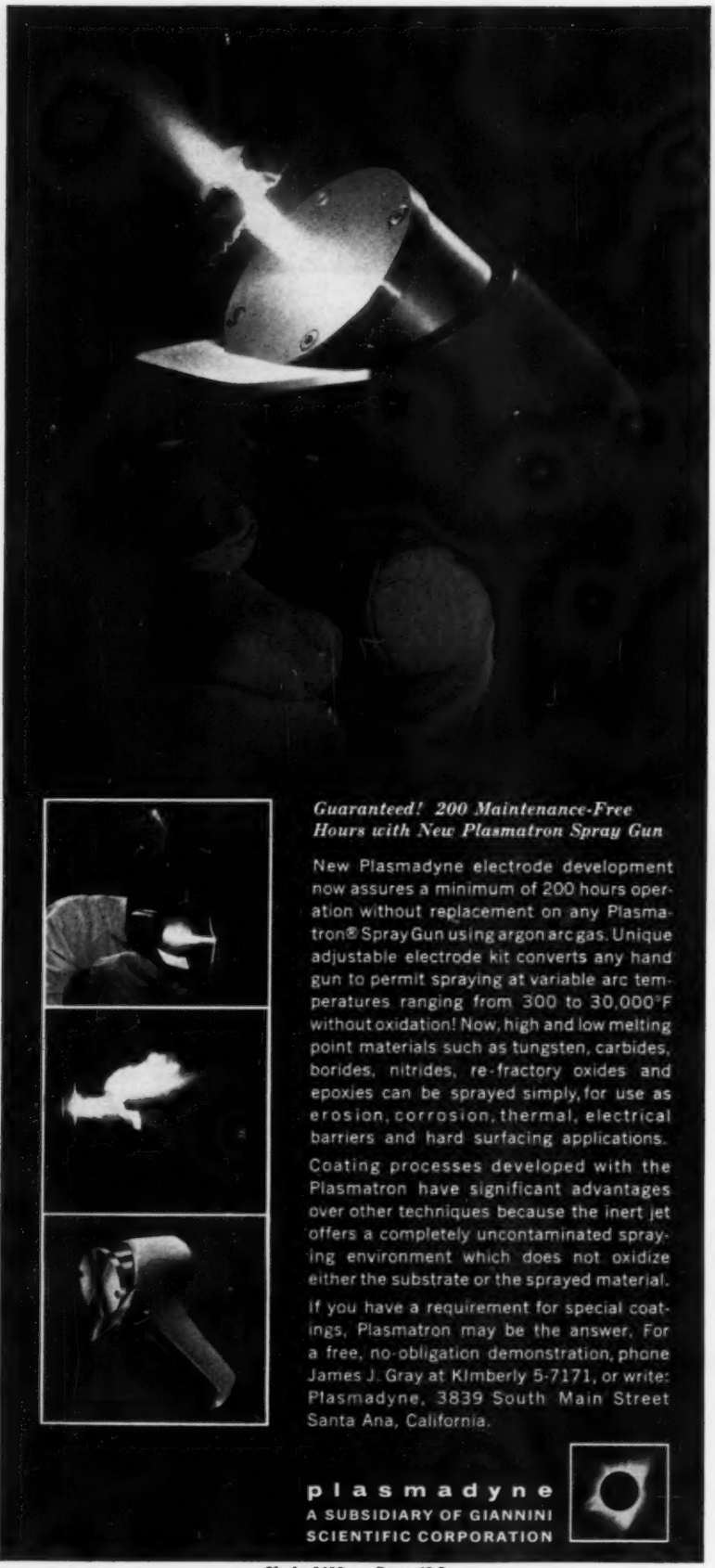
Circle 1638 on Page 48-S



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Circle 1639 on Page 48-B

Cold Work . . .

Other evidence indicated that microstructural changes induced by strain and temperature were responsible for the work softening effect at elevated temperature. Prominent in this respect was the greater weakening induced in specimens heated for long times or at higher temperatures prior to test. The visual microstructural differences between specimens were small, but were confirmed by measurements of mean-free ferrite path. It is clearly shown that, under comparable test conditions, the cold worked steel developed a longer mean-free ferrite path than the unworked steel.

The authors explain the softening at small deformations and hardening at large deformations by visualizing the behavior in terms of two opposing effects of cold work acting in

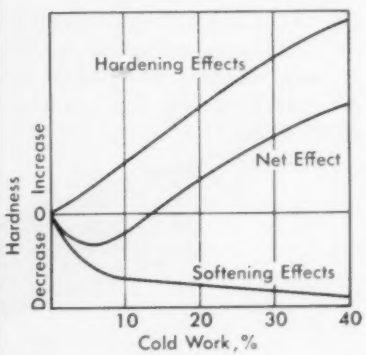

Fig. 1 — Net Hardening Varies Due to Opposing Effects Imposed by Different Degrees of Cold Work

competition, as illustrated in the accompanying figure (Fig. 1). The "hardening effects" of cold work are believed to be due to lattice strains and strain aging (modified somewhat by the recovery of strains upon heating). Contrariwise, the "softening effects" are attributed to the solution of fine carbide particles. The authors further explain that, whereas the hardening effect depends primarily on the condition imposed prior to test, the so-called softening effects occur during the experiment. It is readily seen from the figure that the sum of these effects determines which one prevails as the "net effect".

G. H. Enzian

(More digests on p. 234)

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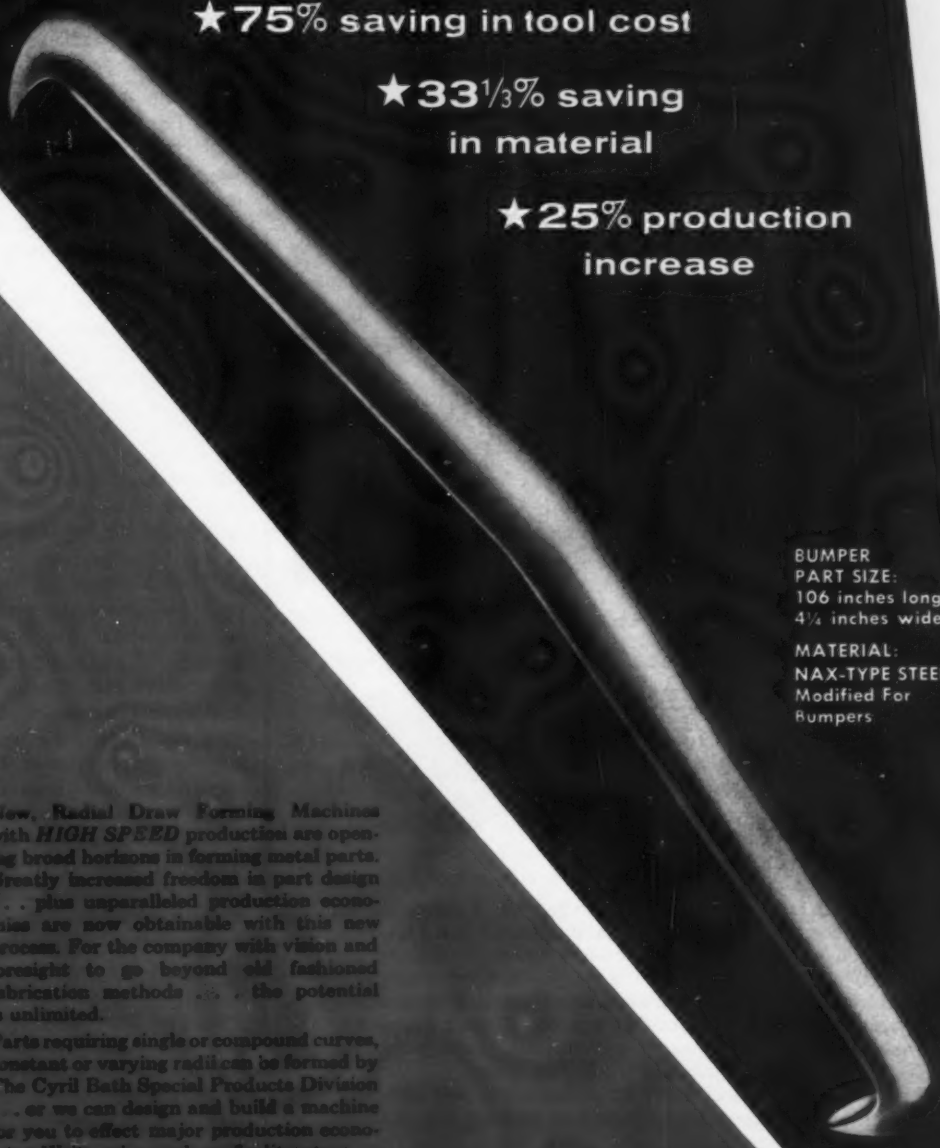

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Circle 1641 on Page 48-B

Phosphorus in Alpha Iron

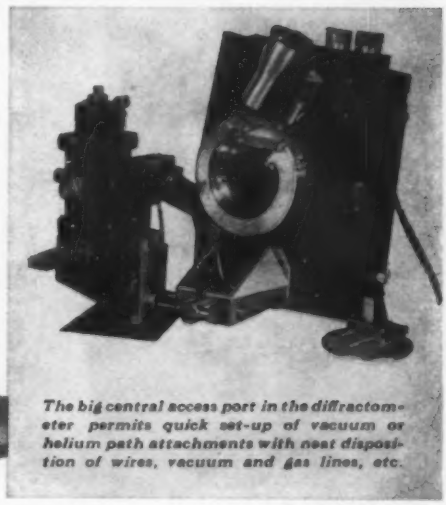
Digest of "Precipitation of Phosphorus from Alpha Iron and Its Effect on Plastic Deformation", by E. Hornbogen. Preprint No. 217, 1960.

THIS WORK IS a part of a larger program on the effects of precipitation from alpha-iron substitutional solid solutions. Phosphorus was chosen first because of its smaller atomic size as compared to iron, and the lack of chemical and crystallographic similarity between the two elements.

Phosphorus has a maximum substitutional solubility of 2.8% in iron at 1050° C. Iron-phosphorus alloys were made containing 0.2, 0.6, 1.3, 1.78, 1.9 and 2.3% phosphorus. After these alloys were homogenized for one week at 1100° C., a solution treatment was sought that would apply to all six alloys. Heating at 1100° C. for 6 hr. was found satisfactory. The tendency to form twins and the hardness of the solution-treated alloys increased with increasing phosphorus. For the alloys containing 1.9 and 2.3% phosphorus, only twinning was found; the deformation mechanism thus changed from slip to twinning with increasing phosphorus content. Phosphorus also causes a slight linear decrease in lattice parameter; this definitely indicates that phosphorus exists in substitutional solution in alpha iron. The high-phosphorus alloys usually showed extensive intergranular brittleness due to segregation of phosphorus at the boundaries. A hot rolling operation before quenching prevented brittleness by changing the high-angle boundaries into a network of sub-boundaries which lock the phosphorus atoms and prevent a high degree of segregation on a single boundary.

The alloys were aged at temperatures equal to about half the solidus temperature in degrees absolute. For the alloy containing 1.9% carbon no change occurred except that the tendency for twinning seemed to increase. After 10 hr. of aging at 500° C., the hardness began to increase, passing through a maximum after about 80 hr. Then hardness decreased. Precipitated particles appear first at large-angle grain boundaries, then at small-angle grain

we're talking here to analytical chemists, crystallographers and metallurgists who know their way around x-ray diffraction and x-ray fluorescence analysis equipment. To people like you the importance of the advances cited below will be abundantly clear. To others of lesser technical background, any local Picker representative will be glad to explain their significance in terms of greater analytic versatility, easier operation, more accurate results.



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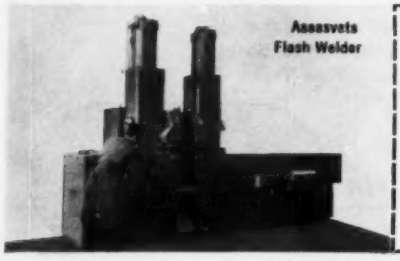

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Circle 1643 on Page 48-B

P in Alpha Iron . . .

boundaries and finally uniformly within the grains.

Electron diffraction was used to study the structure of the initial precipitate, its relation to the matrix and its growth. At the start of precipitation, the particles have a simple crystal structure which consists of a face-centered lattice of iron atoms with a phosphorus atom in the (½, ½, ½) position. If all positions are filled, the structure is cubic and has the composition Fe_4P. The departure from cubic symmetry as shown by the lattice parameters indicates incomplete filling of the cube centers by phosphorus atoms in some definite ordered arrangement (γ'). During overaging, the γ' lattice changes continuously into Fe_3P, the habit plane changing as the structure changes.

Behavior of the particles was observed during plastic deformation in order to understand the hardening mechanism in these alloys. The mechanism of plastic deformation changed from twinning to slip as precipitation started, and slip was the only mechanism found at maximum hardness. When the particle thickness was 200 Å, slip lines either sheared or bypassed them by wavy slip. With coarser particles (500 Å), slip lines were stopped, or bypassed the particles by cross slip on {110} planes. There was some evidence that shearing of the particles was due to stress resulting from dislocation pile-ups at the surface, and not to dislocations from the outside being pushed directly through the particle.

No precipitation (and no hardening) occurred in the alloys containing 0.2 and 0.6% phosphorus. The 1.2% phosphorus alloy does undergo precipitation hardening, but only after long times of aging. The higher phosphorus alloys age more rapidly. Maximum hardness increases linearly with increasing phosphorus content and is always connected with the same size of precipitated particles. Aging at 430° C. caused the maximum hardness increase for the aging periods used.

Precipitation hardening in this system is probably due to the change from the twinning to the slip mechanism of deformation and to the presence of particles forming obstacles to slip. H. P. TARDIF

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. . . as easy to control as a ball point pen
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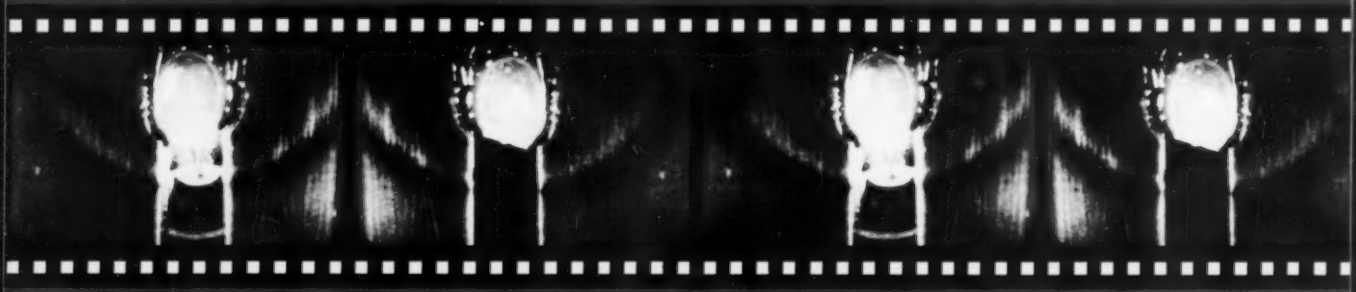
. . . and *consistently* cleaner, smoother, more-uniform welds than any other process.

See the next page for details.

SHORT ARC



Here is a typical LINDE Short Arc weld in the making...

a finished bead, and a weld cross-section...

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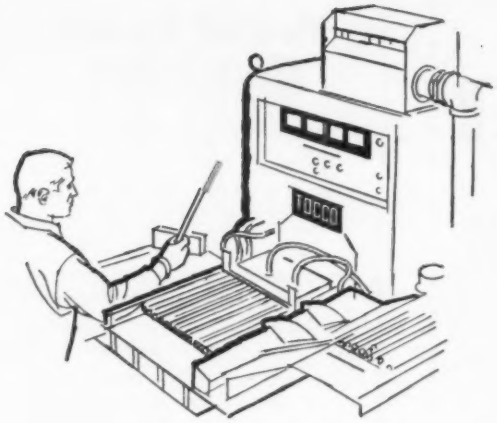

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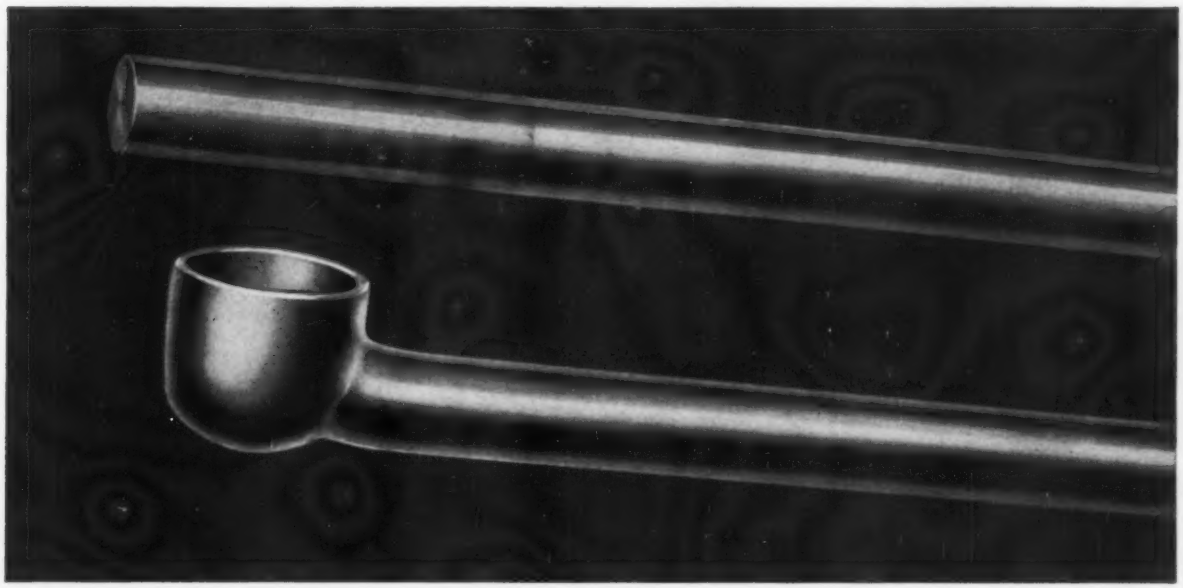

Engineers at Thompson Products Michigan Division of Thompson RamoWooldridge, Inc. recently changed from gas-fired furnaces to fully automatic TOCCO. Application: heating for forging of automotive tie rods. Result: a substantial reduction in direct labor costs, saving thousands of dollars a year on this heating for forging operation. *Annual savings actually amortize the cost of the TOCCO installation in about one year.*

The automotive tie rod shown here is only one of over 500 parts heated for forging in Thompson's new, modern forge plant. *Every one of these parts is heated with TOCCO equipment.*

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Circle 1644 on Page 48-B

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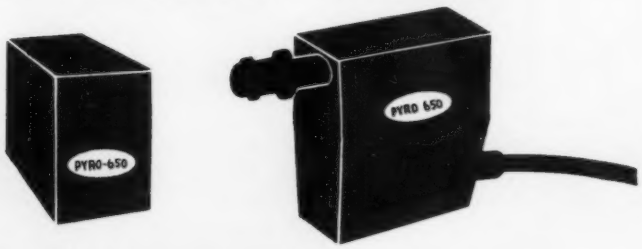

for temperature measurement, recording and control in the ranges from 1100°F to 7200°F and 600°C to 4000°C.

Brightness pyrometers are widely used for non-contacting, high temperature measurements. However, because existing devices are manually operated, their use has been limited to intermittent temperature measurements of short duration.

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Circle 1645 on Page 48-B

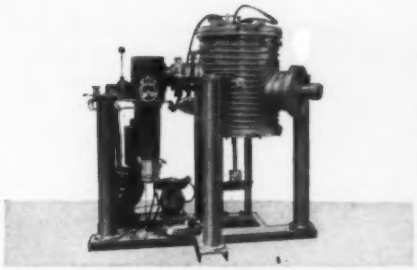
Flow and Fracture Effects in Steel

Digest of "Low-Temperature Flow and Fracture Tension Properties of Heat Treated S.A.E. 4340 Steel", by F. R. Larson and J. Nunes. ⊕ Preprint No. 223, 1960.

CONSIDERING THE MANY USES demanded of heat treated alloy steels, information about the plastic flow properties, particularly at low temperatures, is of considerable interest. Data concerning these properties have been obtained for an S.A.E. 4340 steel in an extensive study of the fundamental plastic flow properties. The characteristics of a variety of microstructures, martensite, bainite, and pearlite were studied at several strength levels. Data on flow stress, strain hardening, fracture stress and fracture strain were obtained by careful "true stress-true strain" tests over a range of temperatures between +200 to −196° C. To make the tests as isothermal as possible, all tests, including those at room temperature, were conducted with the specimen immersed in a liquid and at a controlled constant crosshead speed of 0.01 in. per min.

Because it had been shown elsewhere that considerable deformation can occur after fracture starts, the true stress and true strain at fracture were determined by a special technique. These values were obtained by first plotting the instantaneous readings of diameter against load, then the fracture load was read from the load against crosshead autographic record. This load was then marked off on the diameter against load plot, and a new diameter and load obtained from which the true stress and true strain at fracture were calculated.

The results of the room temperature tests were compared on the basis of strength against ductility by constructing plots of the flow stress at a true strain of 0.04 against the uniform elongation and against the true strain at fracture. The true strain at maximum load followed a general trend which was more or less independent of microstructure. However, there were distinct differences in true strain at fracture that can be attributed to heat treatment. For example, the pearlitic structure



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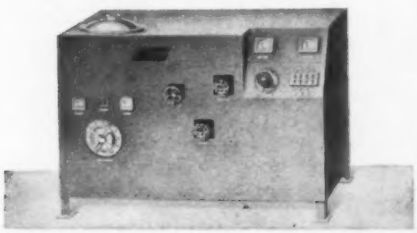

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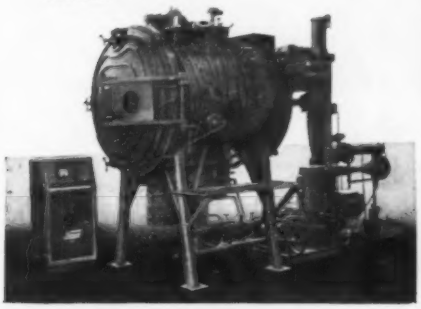

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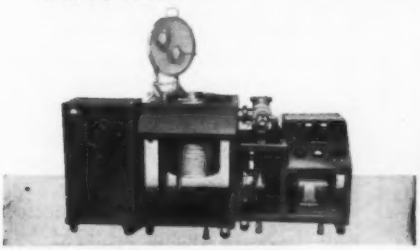

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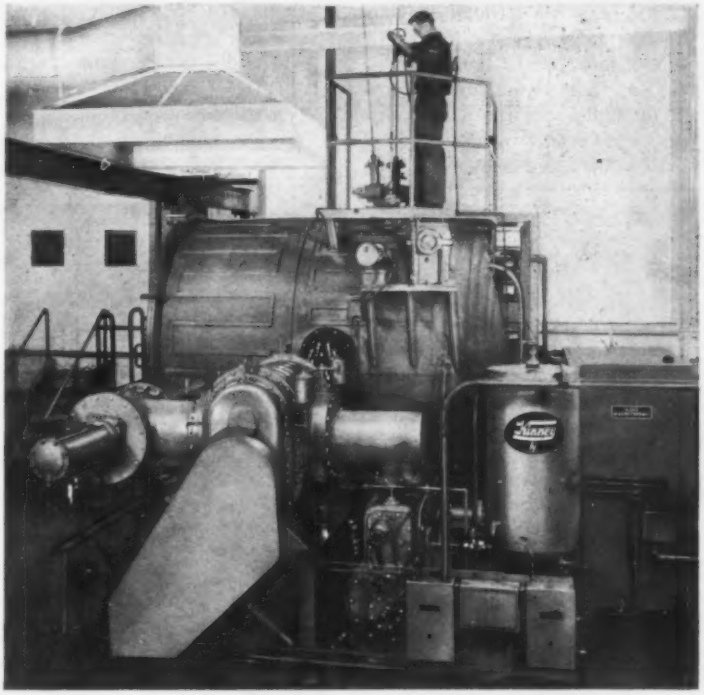

Above, you see a highly versatile KINNEY Vacuum Furnace now in operation at the Watertown Arsenal, Watertown, Mass. In addition to its primary function of Melting and Casting high purity metals, it may be used for degassing atomic materials, sintering carbon molds and alloying reactive metals.

It handles loads up to 1000 lbs. of steel (2200 lbs. uranium) with provision to pour in increments at automatically controlled pouring stations, or pour a full load in 60 seconds. Two interchangeable melting coils, for full capacity and half capacity loads, each provide temperatures up to 3400°F. The pumping system can evacuate the 8' diameter x 11' chamber from atmosphere to 5 microns in 7 minutes and can attain ultimate pressure in the order of .5 micron.

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Circle 1646 on Page 48-B

Flow and Fracture . . .

fractures at strains which are considerably less than those needed for other structures. There was also evidence that heat treatments designed to reduce the amount of retained austenite (double temper, for example) produce larger fracture strains. It is, therefore, quite evident that considerable difference in ductilities can be obtained from one heat of steel by slight modifications in heat treatment.

In analyzing the effect of testing temperature, it was observed that the yield point behavior of the various microstructures was quite different. The bainitic structures showed no evidence of a yield point over the entire temperature range. On the other hand, the magnitude of the yield point effect in the pearlite and martensite increased with decreasing testing temperature and decreasing strength level.

By choosing a true strain of 0.04, yield point effects were avoided. When the flow stress at this constant true strain was plotted against the reciprocal of the absolute temperature, straight lines were obtained for all microstructures and all strength levels. This relationship can be described by the simple empirical equation:

$$\sigma_{0.04} = \frac{M}{T} + \sigma_0$$

where M = slope
T = absolute temperature
σ_0 = interception at T_0.

From this information, it can be seen that, in comparing two different heat treatments of a given steel, the difference in flow stress determined at any testing temperature will prevail throughout the temperature range studied in this investigation. Moreover, if it is determined that the increase in flow stress from room temperature to −196° C. is, say 55,000 psi. for one heat treatment, the other heat treatment will change it the same amount.

Analysis of fracture behavior showed certain general trends of decreasing fracture strain with increasing strength level and decreasing temperature. However, no precise function could be found to describe the behavior, as it is influenced by differences in fracturing mechanism. For this reason, the authors rightfully conclude that considerable more research is needed in the study of fractures, even in a simple tension specimen. G. H. ENZIAN

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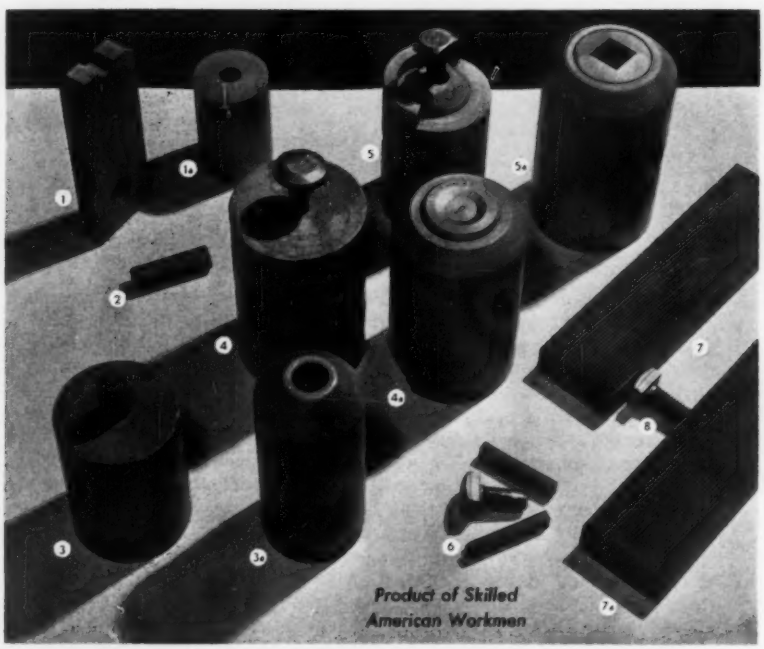

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7 & 7a — Roll thread dies ATMODIE air hardening high carbon high chromium steel
8 — Finished Bolt

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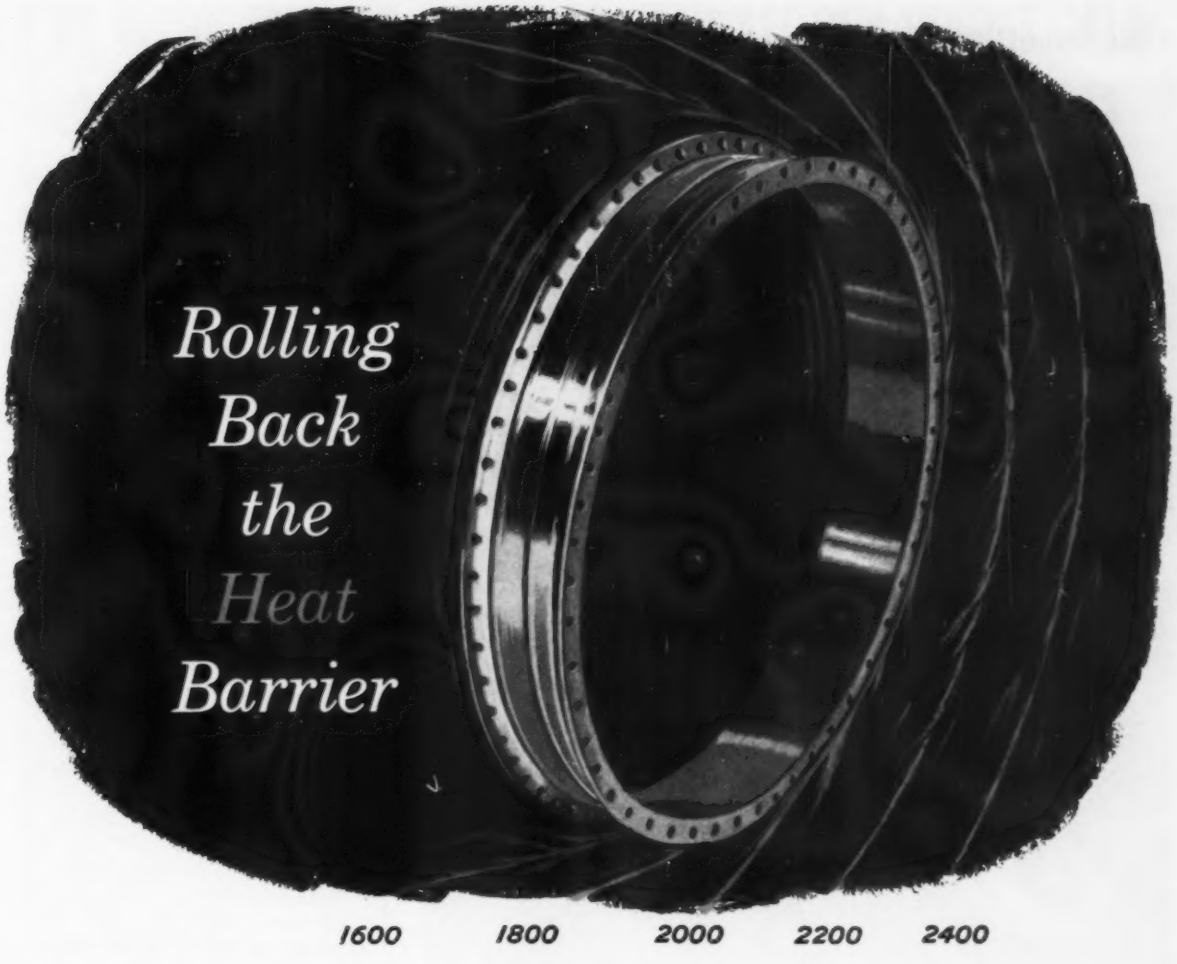
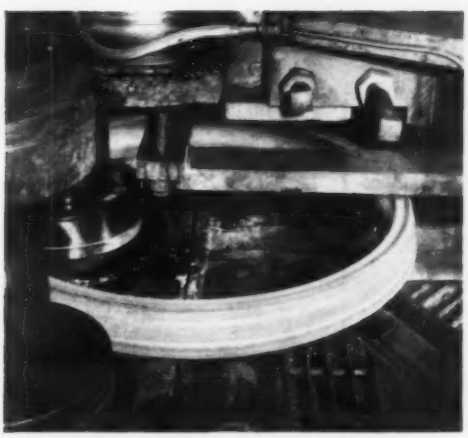
Nickel Embrittlement

Digest of "Embrittlement of High-Purity Nickel", by K. M. Olsen, C. F. Larkin and P. H. Schmitt, Jr. ● Preprint No. 203, 1960.

THIS EXCELLENT PAPER describes a series of carefully conducted experiments on the embrittling effects which very small amount of sulphur (<0.001 wt. %) produce in high-purity nickel under certain conditions of heat treatment.

It is well known that as little as 0.01% sulphur can cause brittle fracture during the hot working of nickel, but that good hot and cold workability is usually achieved by keeping the sulphur below about 0.005%. However, in connection with an earlier study, the authors observed that even nickels having low enough sulphur to permit good forgeability may become embrittled





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Circle 1647 on Page 48-B

Ni Embrittlement . . .

during recrystallization.

By applying a new analytical method for very small amounts of sulphur, and by conducting recrystallization studies on cold drawn, high-purity nickels, it was observed that a nickel containing 0.0009% sulphur became embrittled when heated 30 min. between about 450 and 600° C. A nickel containing less than 0.0001% sulphur was not embrittled, as shown in Fig. 1.

The authors ascertained that embrittlement could not be produced when the sulphur content was below 0.0005%. Also, embrittlement could not be produced except when the nickel was cold worked before heating in the 450 to 600° C. range. Embrittlement did not occur when the wire was first fully annealed at 800 to 1000° C. prior to heat treatment at 500° C. The cold worked nickel could be heated at 800° C. without becoming embrittled.

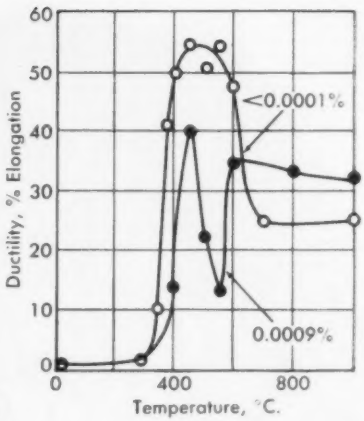

Fig. 1 – Effect of 0.0001% and 0.0009% Sulphur on Recrystallization Behavior of High-Purity Nickel

The addition of 0.01% oxygen or 0.03% manganese had little effect on the embrittling behavior, but an addition of 0.03% magnesium eliminated embrittlement.

The authors postulated that nickel sulphide is precipitated early in the recrystallization stage, and carried along in the boundaries with further grain growth. At the higher annealing temperatures, the sulphide is believed to diffuse back into the nickel matrix, restoring ductility.

Embrittlement was eliminated by magnesium presumably because the sulphur was tied up as an insoluble magnesium sulphide which was uniformly dispersed throughout the matrix.

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Circle 1648 on Page 48-B

Self-Diffusion in Single Crystals

Digest of "Self-Diffusion in Nickel Single Crystals", by A. Messner, R. Benson and J. Dorn. ⊖ Preprint No. 193, 1960.

THIS INVESTIGATION was conducted prior to a study of the effect of straining on self-diffusion in metals. Radioactive Ni_{63} was diffused into single crystals of nickel. (Ni_{63} has a half-life of 85 years and is easy to detect by a sensitive surface monitoring technique.) Nickel single crystals were prepared under helium atmosphere by the Bridgman technique. After machining and electrolytic polishing, specimen size was $2 \times \frac{1}{2} \times 1/10$ in. A layer of Ni_{63} approximately 1000 atoms thick

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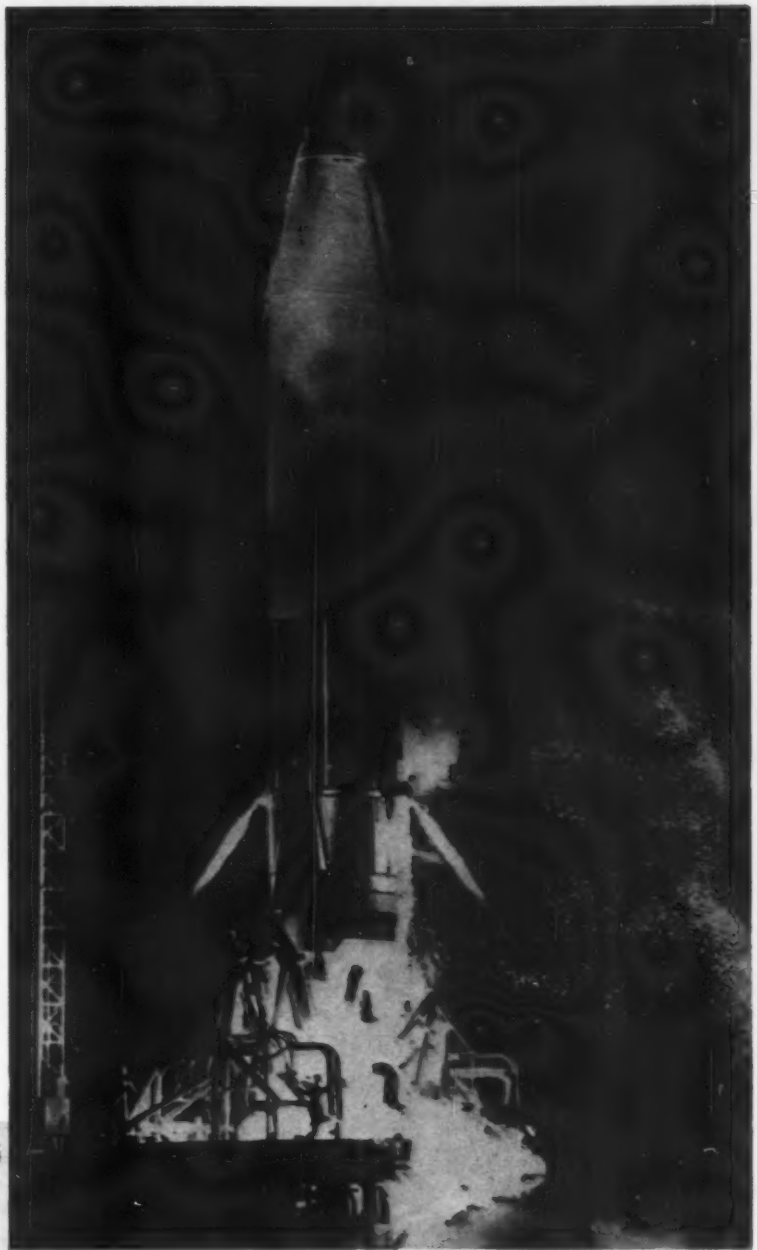

The failure of a single component can put even the mighty Atlas Missile out of commission. That's why an electroplate of SEL-REX BRIGHT GOLD is specified to give an extra measure of reliability to Elco's patented VARICON Contacts used in missiles, rockets, computers and similar critical applications.

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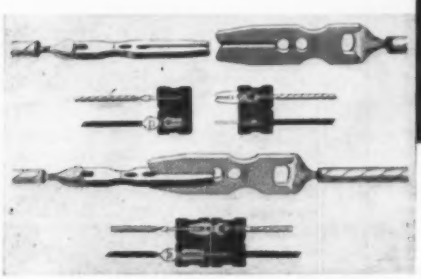

Photo shows Elco's patented Varicon Connectors and unique fork-like contact plated with Sel-Rex Bright Gold.

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Circle 1649 on Page 48-B

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Brazing Speeds Building of Jet Engine Diffuser

The stringent design requirements of this diffuser assembly were met by stainless furnace brazing. The number of manufacturing operations were also reduced, cutting total cost.

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Inaccessibility prevented machining after assembly, so allowable tolerance was only (plus or minus) .002". Precision application of brazing filler metal and of furnace temperatures kept distortion within the limits.

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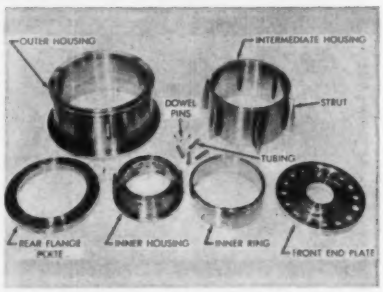

Wall Colmonoy Stainless Furnace Brazing Gave These Important Benefits:

- Brazed joints as strong as parent metal
- 13 parts joined in one brazing operation
- Distortion held to within ±0.002"
- No finish machining was needed
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Circle 1650 on Page 48-B

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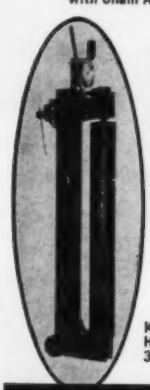

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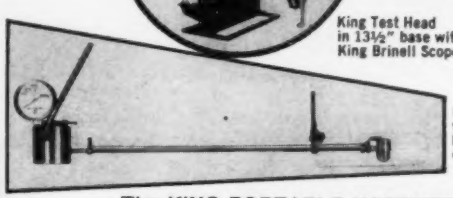

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Circle 1651 on Page 48-B

Self-Diffusion . . .

was electroplated onto the specimens. Diffusion anneals under argon atmosphere were conducted at 680, 710, 750, 775, 800 and 830° C. Surface activity was measured by using a windowless flow counter containing geiger gas (99% He and 1% isobutane). Periodic evaluations of surface activity were made during the anneals.

Surface activity of a specimen plated with an infinitely thin layer decreases according to

$$\frac{I}{I_0} = \exp\ (\mu^2 Dt)\ \text{erf}\ (\mu^2 Dt)^{\frac{1}{2}}$$

where

I_0 = surface activity at time = 0
I = surface activity at time t
t = duration of the anneal
D = Diffusivity
μ = linear absorption coefficient for radiation in the diffusing system.

For these experiments, $\mu^2 Dt$ increased linearly with time for all temperatures and times except near $t = 0$. Variation near $t = 0$ occurred because of the initial time required for nickel to diffuse toward the surface.

The mean value of the linear absorption coefficient, μ, calculated from the data was $1.3 \pm 0.1 \times 10^4$ per centimeter. Using this value of μ, the diffusivity, D, was calculated for each anneal temperature. D varied linearly when plotted as a function of the reciprocal of absolute temperature. The self-diffusivity in nickel single crystals is given by the equation

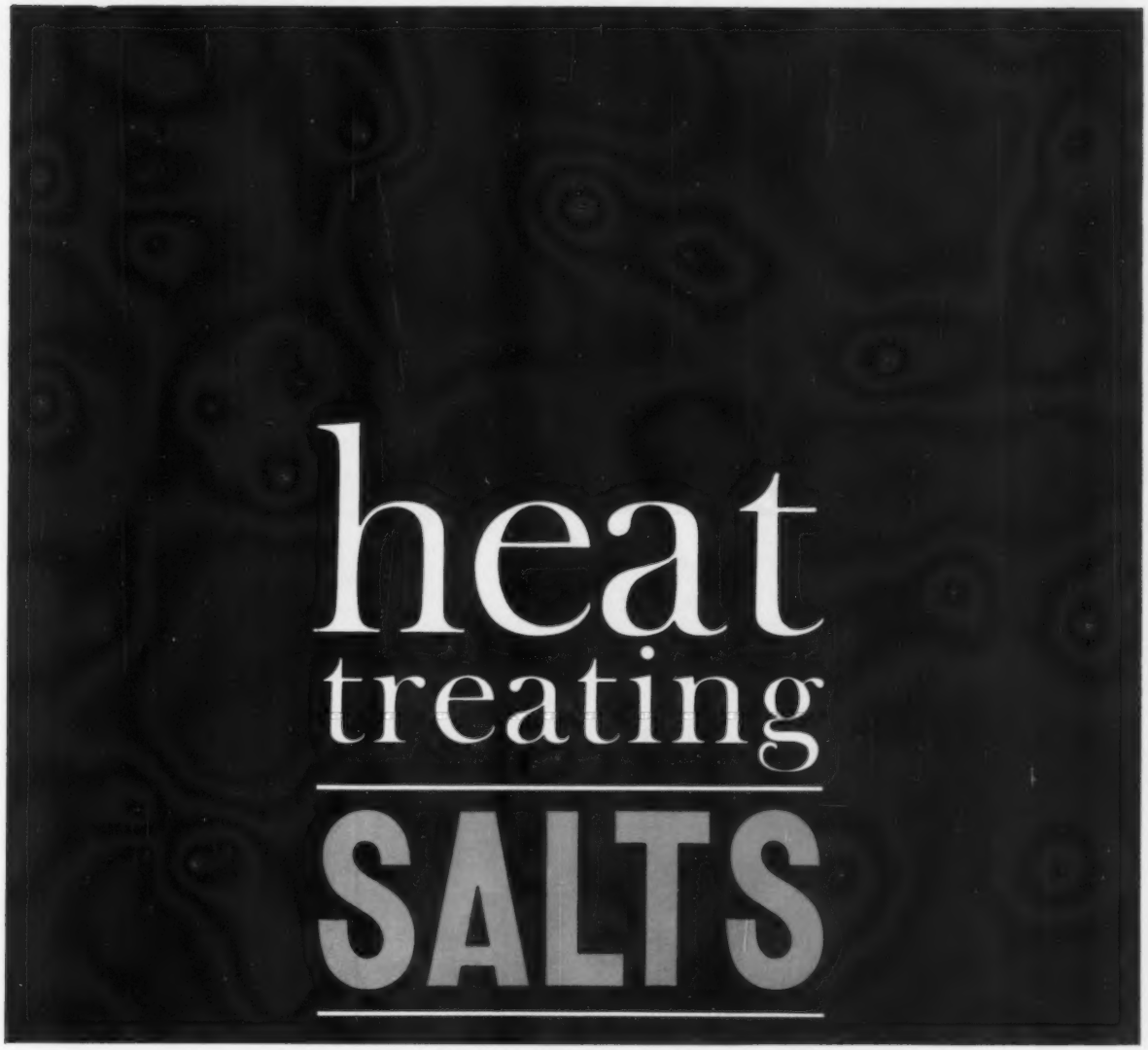
$$D = 5.8 \pm 2.0^{69,700/RT}$$

DAVID KRASHES

Phosphorus in Stainless Steel

Digest of "The Effect of Phosphorus on the Elevated-Temperature Strength and Weldability of Some Low-Carbon Austenitic Stainless Steels", by G. R. Rundell and R. J. Raudebaugh. Preprint No. 194, 1960.

FROM PRELIMINARY TESTS and a review of the literature, phosphorus was chosen as an element which might increase creep-rupture properties in austenitic stainless steels. These observations were to establish that the element would not be detrimental to low-temperature



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Circle 1652 on Page 48-B

P in Stainless . . .

ductility or weldability. Measurements reported on the high-temperature properties and on the hot ductility of several small heats indicate that phosphorus will markedly improve high-temperature strength of both Type 304 and Type 316 stainless steels. Further, weldability is not adversely affected if the carbon content is kept below 0.03% and the nickel content is kept in the lower end of the specification. Since variations in free ferrite in the weld area were influenced by phosphorus content, Charpy impact tests were carried out to determine the embrittling effects which might result. The transformation of retained ferrite in welds to sigma phase results in a decrease in impact strength but the drop is not serious.

Although the constitution diagram was not established in detail, the effects of carbon, nickel and phosphorus content can be correlated very well with the suggested constitution diagram for the austenitic alloys. It should be possible to predict the effects of variations in phosphorus, nickel and carbon (as well as other elements) on the weldability and embrittlement characteristics from information concerning their effects on ferrite stability and the peritectic temperature and composition relations. The results suggest that phosphorus additions to stainless steels will produce a valuable new class of materials, providing we balance the composition to take full advantage of this effect.

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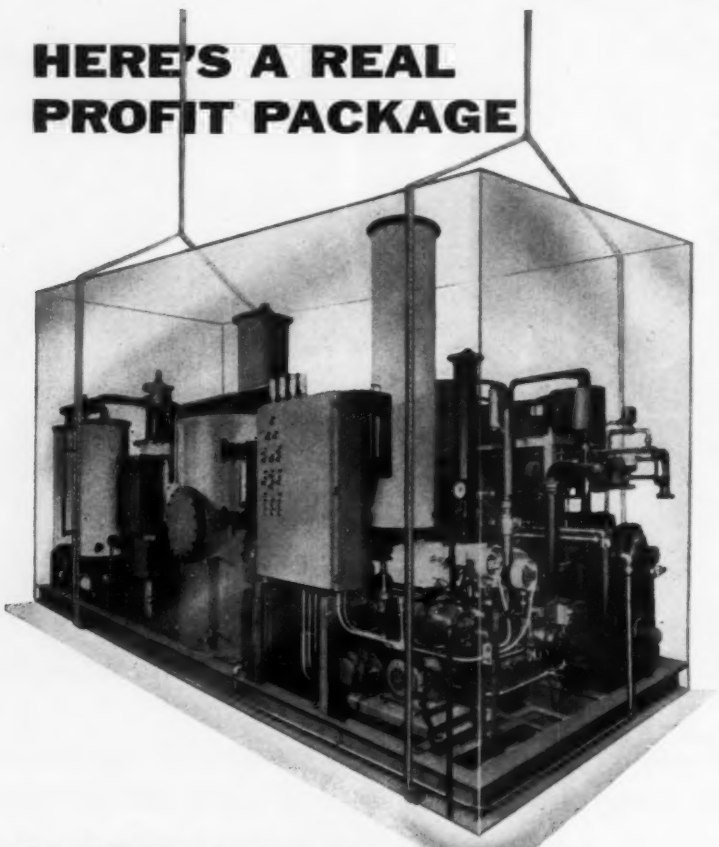

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Circle 1653 on Page 48-B

Cb-C System

Digest of "Columbium-Carbon System", by R. P. Elliott. ⊖ Preprint No. 179, 1960.

THE SYSTEM was determined by X-ray and metallographic examination of sintered and arc-cast alloys (which were produced from electron gun refined columbium, high-purity columbium powder and high-purity lampblack). Three separate techniques were employed in producing the alloys. Columbium was arc melted with either a 6% or 1.5% carbon master alloy to prepare alloys in the 0.1 to 5.5% carbon range; columbium powder was sintered with lampblack to produce alloys for X-ray examination, and sintered compacts were arc melted for as-cast structures in the higher-carbon region.

Heat treatments were carried out at temperatures up to 2000° C. with an evacuated resistance furnace being employed at 1500 and 2000° C. Specimens were suspended in a molybdenum wire basket, and quenched by contact with the water cooled hearth of the furnace. Below 1500° C., specimens were encapsulated in Vycor or quartz tubes and heated in resistance tube furnaces.

The solid solubility of carbon in columbium was determined to be 0.80 wt.% at 2230° C.; this decreased rapidly to 0.10% at 1800° C. (This is far in excess of that previously reported.) Two carbides of columbium exist, hexagonal Cb_2C having a limited region of solubility between 5.43 and 5.83 wt.% carbon, and face-centered cubic CbC with a wide solubility range between 8.25 and 10.25 wt.% carbon. A eutectic

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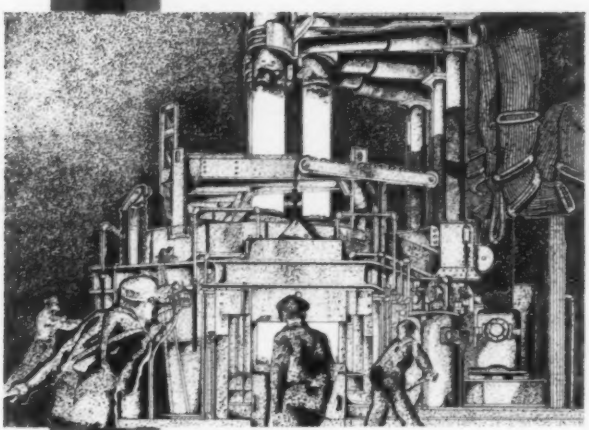

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Circle 1654 on Page 48-B

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Circle 1655 on Page 48-B

Cb-C System . . .

exists at 1.5 wt.% carbon with the liquid freezing to form $Cb_{0.80\%\ C}$ + Cb_2C at 2230° C. This reaction was determined by incipient melting techniques. There is evidence for a peritectic reaction L + CbC (where L signifies liquid) to form Cb_2C at an undetermined temperature.

An intermediate solid solution

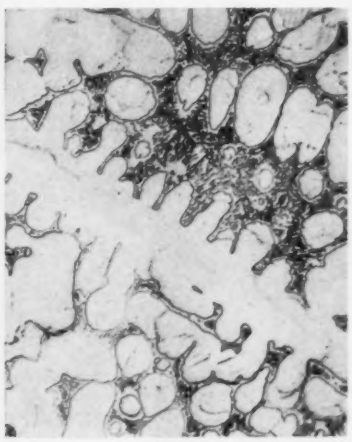


Fig. 1 — Columbium Alloy Containing 4.34% C, as Cast. Proeutectic Cb_2C in matrix of Cb-CB_2C eutectic. Evidence of peritectic reaction. 250 ×

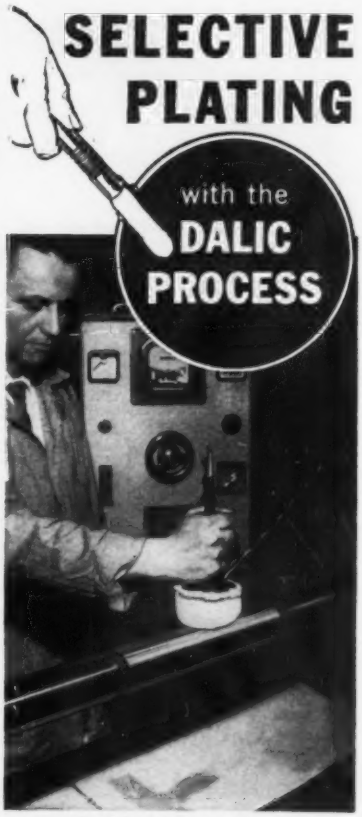
(E) between CbC and Cb_2C has been hypothesized by other investigators. Although careful scrutiny of X-ray data was made, no evidence of such a phase was found. Alloys richer in carbon than the CbC phase freeze by the eutectic reaction liquid going to CbC + graphite at 3250° C.

W. R. OPIE

Transformations in Titanium Alloys

Digest of "Beta Transformation Characteristics of Titanium Alloys With Vanadium and Aluminum", by E. L. Harmon and A. R. Troiano. Preprint No. 181, 1960.

THE 16 V, 2.5 Al titanium alloy is a metastable alloy which can be readily formed after solution treatment and before the final aging. The authors determined the isothermal transformation behavior for this alloy after quenching from the beta field and from the alpha-beta



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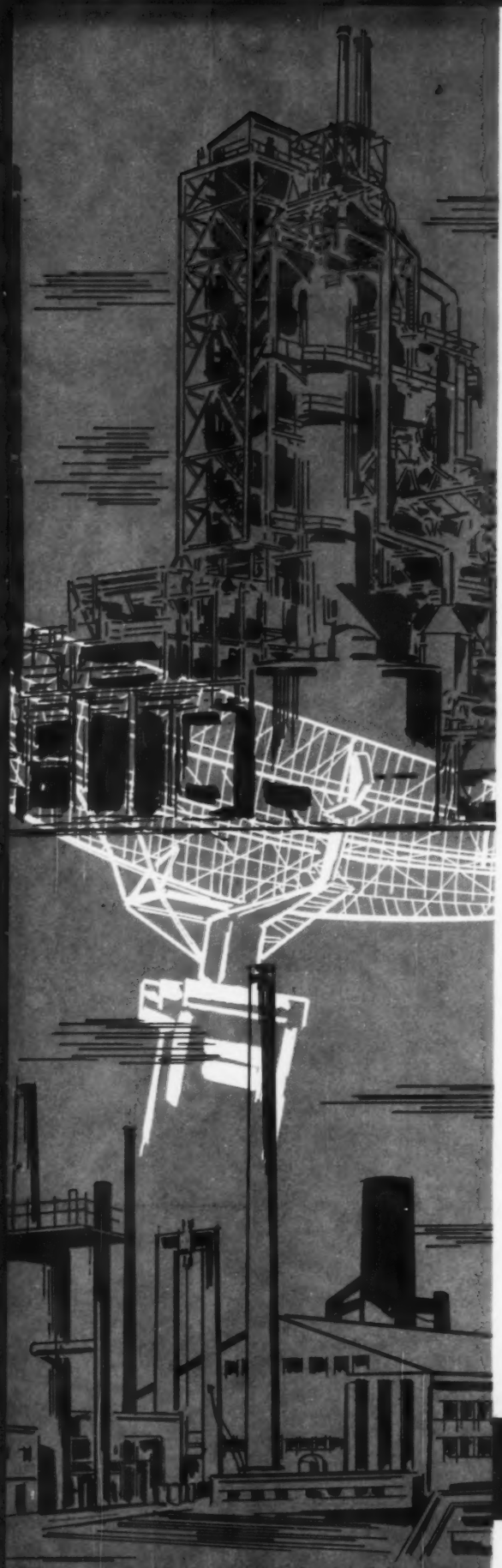

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Circle 1657 on Page 48-B

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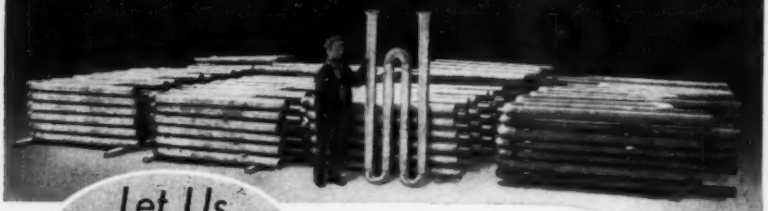

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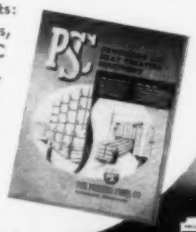

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Circle 1658 on Page 48-B

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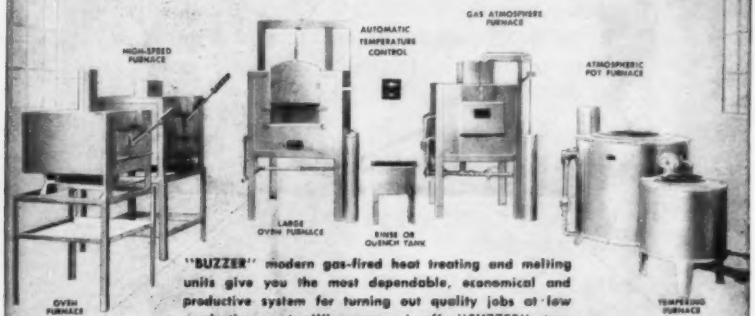

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Circle 1659 on Page 48-B

Ti Alloys . . .

field. In each instance, TTT-diagrams were obtained for both direct quenching to the transformation temperature and quenching to room temperature followed by aging at the transformation temperature. A comparison of the behavior of this alloy and that of 20% V titanium binary was made.

The addition of aluminum to the binary significantly retarded the formation of the omega phase and lowered the temperature range in which the alpha phase is the first decomposition product. Transformation kinetics were similar for specimens quenched directly to the reaction temperature and for specimens quenched to room temperature and subsequently aged at the reaction temperature.

A new stage in the decomposition of the beta phase was observed at aging temperatures below 270° C. Instead of decomposing into omega phase, the beta formed two body-centered cubic phases. A similar observation was made in a 20% V titanium binary alloy. The authors discuss the sequence of structural changes in the latter alloy in terms of a hypothetical free energy-composition relationship.

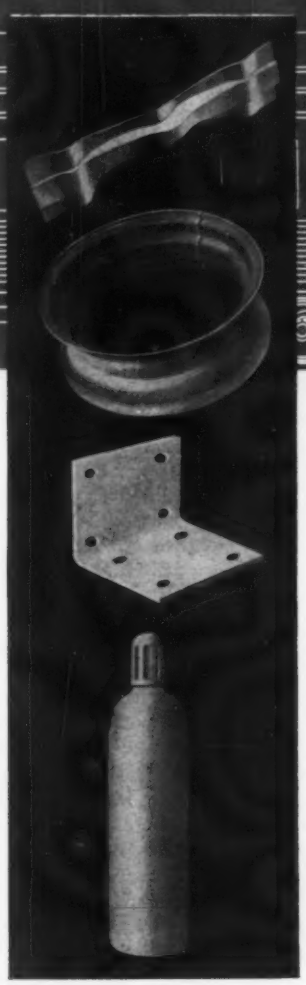
P. D. Frost

Nuclear Fuels of Liquid Metal

Digest of "Liquid Metal Fuel Constitution", by D. G. Schweitzer and J. R. Weeks (in two parts). Preprint No. 195 and 196, 1960.

Solubility of Uranium in Bismuth

The more advanced concepts in nuclear power reactors make increasing use of liquid metals and, particularly, their alloys—as fuels, as coolants, and as heat exchange mediums. The use of liquid metals in such reactors requires an accurate knowledge of the solubilities (in the liquid metal carriers or heat exchange mediums) of nuclear fuels and of possible container materials. Obtaining exact information requires frequent, accurate sampling and precise analytical techniques. This section of the paper is concerned largely with the equipment and techniques



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Circle 1660 on Page 58-B

Nuclear Fuels . . .

used in the study of the solubility of uranium in bismuth from 300 to 725° C. and with the factors influencing the accuracy of the results.

Accurate solubility determinations required care in the selection of materials and in their further purification. Reagent-grade helium was purified successively in a liquid air-cooled, charcoal cold trap and a titanium chip tank at 850° C., then tested by passing over polished uranium at 600° C. If the uranium tarnished, the gas was not sufficiently pure. Bismuth of 99.999% purity was further purified by hydrogen-firing at 600 to 700° C. Uranium with less than 100 ppm. impurities initially, and diluted in the experiments by more than a factor of 10, contributed less impurities than the bismuth.

High-purity graphite was degassed and, in some instances, hydrogen-fired at 800° C. Analyses to determine the impurity contribution to the solutions by molybdenum crucibles indicated a slight increase in copper content, 5 to 15 ppm. over a two-week period in one instance, but no other significant contribution.

A high-temperature high-vacuum system was used for continuous rapid determination of liquid metal solution compositions. It consisted of two vacuum chambers, separated by a valve, and arranged so that either chamber could be independently evacuated or pressurized with purified hydrogen or helium. The upper chamber could be opened to permit materials or sampling devices to be added without contaminating the atmosphere in the furnace chamber.

The liquid bismuth was purified within the system by purified hydrogen passed through the filter. Sampling was done with an inert sampler of graphite, pyrex, vycor, tantalum or molybdenum, with a thermocouple arrangement capable of measuring temperature to ± 0.5° C. at the exact time of sampling. Errors introduced by the equipment were generally less than those due to chemical techniques in solution analysis.

In determining the solubility of uranium in bismuth, a variety of materials was used for samplers and crucible. The data are essentially the same regardless of sampling techniques or equipment materials. The solutions were held at temperature for periods of from 3 hr. to 17 days, and samples were taken on both the heating and the cooling cycles with no significant differences. Thermocouples and temperature readings were checked by measuring the freezing point of bismuth in the uranium-bismuth solutions to 271.3 ± 0.3° C. The uranium solubility curve can be approximated by the equations wherein

$$\log_{10}(\text{ppm. U}) = 6.585 - \frac{2240}{T} \quad (\pm 2\%)$$

(300 to 480° C.)

$$\text{or } 7.263 - \frac{2744}{T} \quad (\pm 10\%)$$

(480 to 725° C.)

UBi_2 is the solid in equilibrium with the melt at the temperature studied.

Since graphite is a potential nuclear structural material, particular consideration was given to the effects of using graphite crucibles on uranium solubility in bismuth. When large excesses of uranium were present in the systems, no effects on its solubility were observed. However, when uranium in small excess of the saturation value was placed in graphite crucibles containing bismuth, the uranium solubility was considerably reduced. This reduction in solubility was not affected by additions of magnesium, used as a deoxidant, or of zirconium used as an inhibitor for uranium-graphite reactions.

The investigation showed that all the uranium originally added in the experiments could be driven back into solution at higher temperatures,

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Circle 1661 on Page 48-B

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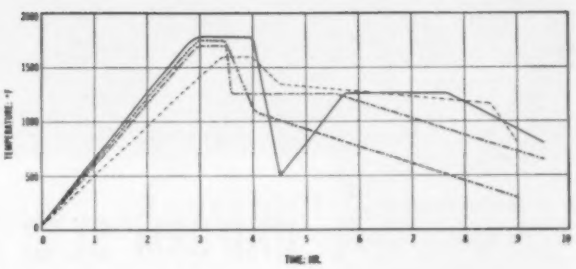

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Nuclear Fuels . . .

which posed the problem of possibly concentrating uranium in the core of a reactor. This established a need for additional work to obtain information to be used in the control and operation of a reactor.

Liquidus Curves of U-Zr-Bi System

A uranium-bismuth fuel solution can effect mass-transfer of iron and chromium in a piping system. Additions of zirconium can partially inhibit this, but zirconium also reduces the solubility of uranium in bismuth. For this reason, the liquidus of the significant bismuth-rich corner of the U-Zr-Bi system was determined in this study. Since magnesium to the extent of 1% is also a potential addition to such solutions (to prevent possible oxidation of the uranium), its effect on the ternary eutectic was also studied.

The uranium solubility in bismuth is not affected by concentrations of less than 0.015% zirconium. However, a significant reduction in solubility occurs above a 0.125 Zr/U atomic ratio. The possible existence of solid U-Zr-Bi ternary phases is suggested by the shape of the liquidus curves. Extrapolation of tie lines from the cooling curves produced straight lines on the ternary plot, converging at the bismuth origin. These indicate the precipitation of uranium and zirconium in fixed ratios from each solution, equal to their ratio in the original alloy between Zr/U atomic ratio limits of 0.125 to 0.74. They also suggest a ternary solid phase with a wide homogeneity range of these ratios.

Photomicrographs of samples of different alloys cooled in helium from the liquid state from 700° C. showed a number of different intermetallic compound particles. A binary alloy of 0.474% U in bismuth contained a U-Bi compound, UBi_2. A 0.55% Zr alloy contained a Zr-Bi intermetallic compound whose composition could not be determined by tie-line extrapolation because the melts were too dilute. Ternary alloys with Zr/U ratios less than 0.74 contain one or more ternary compounds of undetermined composition. Alloys with Zr/U ratios greater than 0.74 contained both Zr-Bi and ternary compounds.

Magnesium additions of 1% had no effect on the U-Bi or the Zr-Bi binary liquidus, but had a significant effect on the ternary liquidus. The investigation indicated that the magnesium did not enter the ternary compound, but did increase the solubility of the compound in bismuth.

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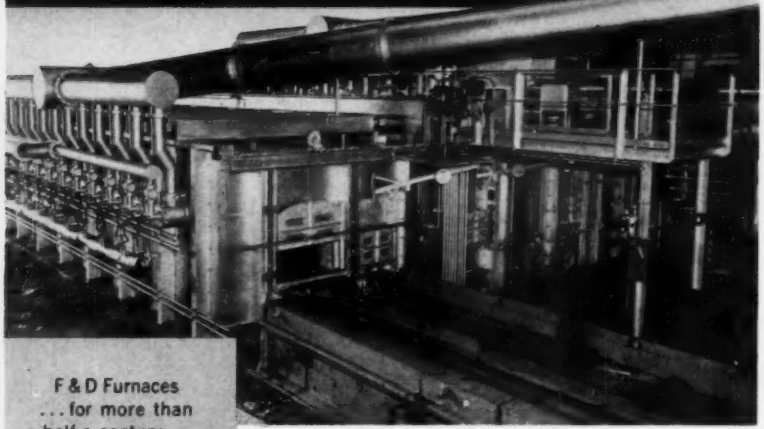

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Basal Slip in Magnesium

Digest of "Activation Energies for Basal Slip in Magnesium Single Crystals", by T. A. Trozera, J. Mote and J. E. Dorn, Preprint No. 186, 1960.

ONE OF THE TECHNIQUES for determining the mechanism of crystal deformation, particularly at elevated temperatures, is a comparison of the *observed* activation energy for the deformation process with the value *calculated* for the several mechanisms which might be possible. Professor Dorn and his co-workers in the past have applied this technique in a variety of situ-

ations. Here, they compare measurements on magnesium single crystals which are oriented for basal slip with the mechanisms which have been proposed for this deformation.

The results in this work, tieing a ΔH value to a particular mechanism, are less straightforward than for the previous work on aluminum. There are no unique values, the activation energy being a linear function of the temperature. The value of ΔH over the whole temperature range is different from the activation energy for self-diffusion. These results do not agree with those of Conrad and Robertson who assumed a constant ΔH, although the latter used a different method of calculation.

An observed "anomalous" creep behavior in an intermediate temperature region raises some question about the possibility of reasoning from activation energy to mechanisms in this particular situation. This behavior shows up as a very high stress dependence of the creep rate.

At low temperatures, the activation energy observed agreed with that for a process of dislocation intersection, although it would seem that the actual magnitude of the creep rate is lower than expected for this kind of model. The researchers found poor agreement with the expected value for any mechanism in the high-temperature region, although they suggest that it is not unreasonable to fit a model involving the motion of jogged screw dislocation. The results suggest that considerable work must be done yet in determining the controlling factors in the deformation of even such simple systems as basal slip in magnesium. R. W. GUARD

Size Effect in Notched Bend Tests

Digest of "Temperature and Microstructure Dependence of Size Effects in Notched Bend Tests of Some Alloy Steels", by S. Yukawa. Preprint No. 238, 1960.

THE RELATIONSHIP OF TESTS on laboratory specimens to the service performance of large structural members is of great practical interest. More basically, the dimensional effects of test specimens can provide clues to the importance of factors such as stress state, stress gradient, constraint and stored energy on strength and fracture behavior.

Work on this problem was carried out on large alloy steel rotor forgings. The microstructure was tempered bainite accompanied by proeutectoid ferrite, except for those instances where the effect of microstructure was studied. The specimens were square (in cross section) with a 45° included angle and a 20% depth notch across one surface at mid-length. The notch radius "r" to specimen size "a" relationship was denoted by the parameter a/40r. The specimens were loaded as simple beams with the notch in tension, and the strength values obtained from the maximum bending moment attained divided by the section modulus of the net area under the notch.

In a first series of tests the effect of size on strength was negligible in unnotched specimens, moderate at intermediate notch acuity and very pronounced in the sharply notched

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Circle 1665 on Page 48-B

Notched Bend Test . . .

series. When the temperature was varied, strength increased over a temperature interval to a constant value at the higher temperature for each particular geometry. The temperature range of strength increase is higher, and the magnitude of the increase is greater, for larger specimens and more severe notches. The typical brittle-to-ductile transition in fracturing behavior occurred in each series with the brittleness persisting to a higher temperature with increasing size and notch acuity.

Comparisons were also made of the notched bend strength of tempered bainite and tempered martensite. The difference between the two increases considerably with increasing size. Moreover, the fractures in the tempered martensite were ductile at all specimen sizes, while they became brittle with increasing size in the bainitic specimens. Evidence showed size effect sensitivity can be related to standard Charpy V-notch transition temperature of the steel.

For steels of low transition temperatures, the bend strength reduction between ⅝-in. and 4-in. specimens, due to combined size and notch acuity effects, was around 15%, while for high transition temperatures the strength reduction was as much as 75%. This gives added significance to this test in studies on alloy steels.

Results have also shown that lowering the transition temperature is a more effective means of attaining high bend strength in large severely notched specimens than increasing the tensile strength. The bend strengths of small specimens increase in proportion to the tensile strength, but the strengths of large specimens reach a maximum and then decrease with increasing tensile strength.

The effect of specimen size on the strength of bend specimens with severe notches was considered in terms of the energy balance concept of fracture and Griffith's theory of fracture propagation. This concept predicts that nominal bend strength will vary inversely with the square root of specimen size; this was verified. The straight lines obtained also defined a G_c value of 120 lb. per

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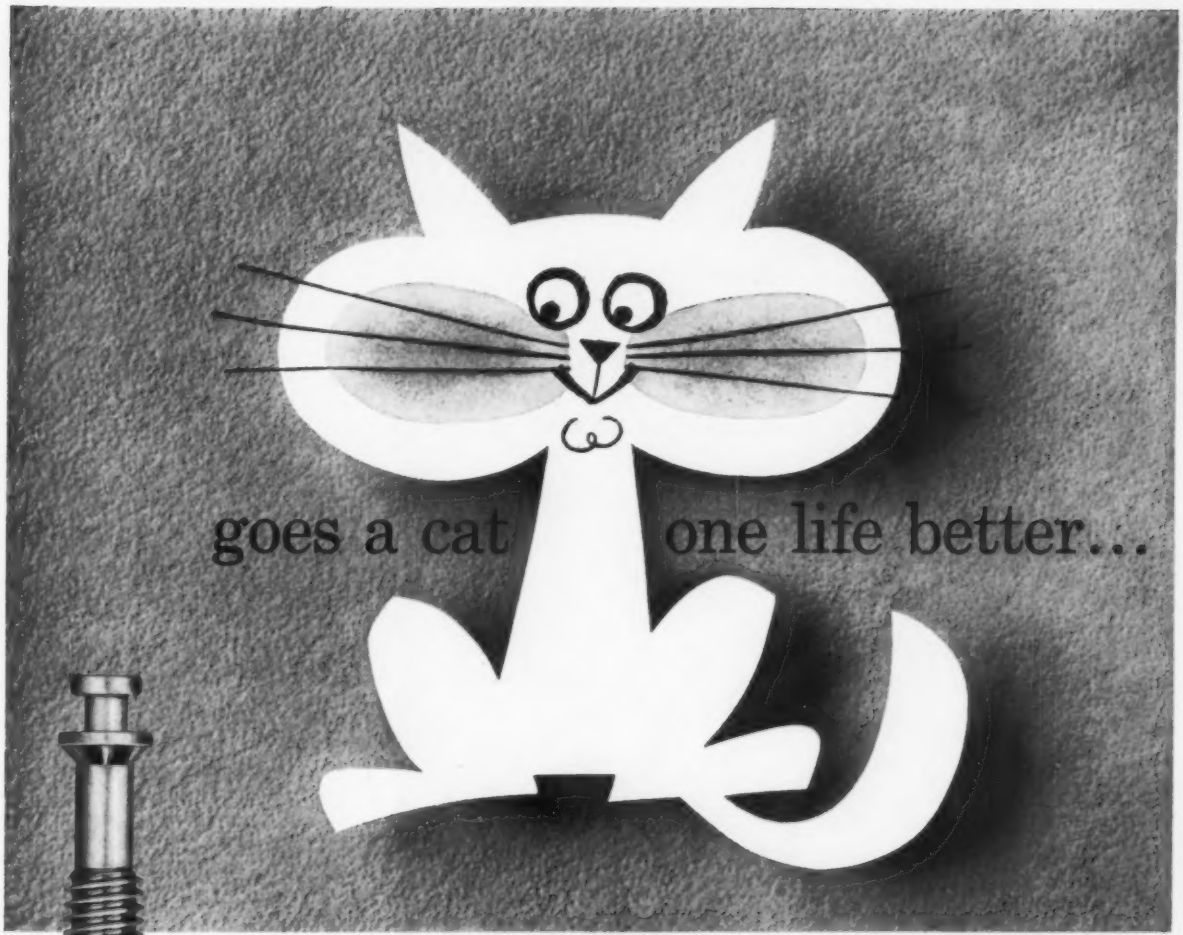

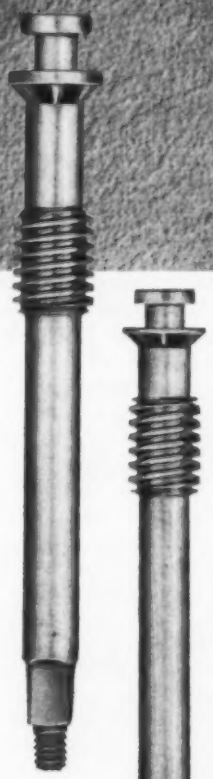

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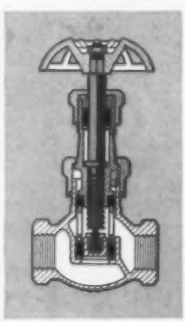

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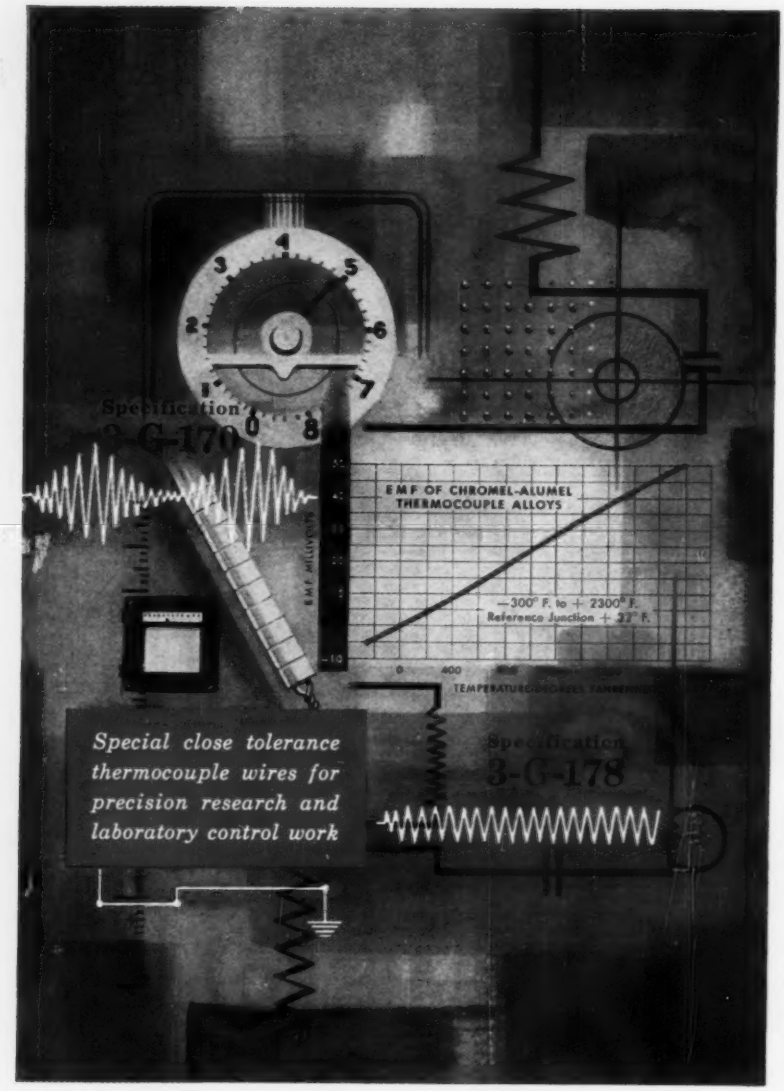
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Circle 1668 on Page 48-B

Notched Bend Test . . .

in., G_c being defined as fracture toughness or critical energy release rate.

This relationship between V-notch Charpy 50% fibrous transition temperature and size effect sensitivity of the steel, has been used recently in alloy development studies. The bursting strengths of internally notched spin test specimens has also been related to transition temperature during the development of steels for large turbine-generator rotors. H. P. TARDIF

Microstructure of Electrical Steel

Digest of "The Microstructure of Low-Carbon 3.25% Silicon Steel", by W. C. Leslie, R. L. Rickett, C. P. Stroble and G. Konoval. ⊜ Preprint No. 226.

THE RESULTS of a thorough study of the microstructure of this very important electrical steel are discussed in relation to the constitution diagram and heat treatment of the material. Though much of the information is probably known by the mill metallurgist, this paper brings together a wealth of structural data. Electrical and magnetic property information would have been desirable, but obviously such information is highly proprietary.

Austenite in these steels may amount to as much as 6 to 8% after heat treatments at 2000 to 2100° F. It can be eliminated as a constituent by heating to 2100 to 2450° F. for periods up to an hour. This temperature is 150 to 250° higher than indicated by the equilibrium diagram. Austenite may be formed on cooling from the temperature above 2100° F. if the steel remains for several minutes in the temperature range around 1950° F.

Both martensite and proeutectoid ferrite are formed when steels containing austenite are cooled. The nature of the transformation product depends largely on the mode of formation of the ferrite.

Two unidentified constituents have been observed on heating in the neighborhood of 1200 to 1400° F. It is presumed that these are some type of modified carbide or nitride. The isothermal precipitation of car-

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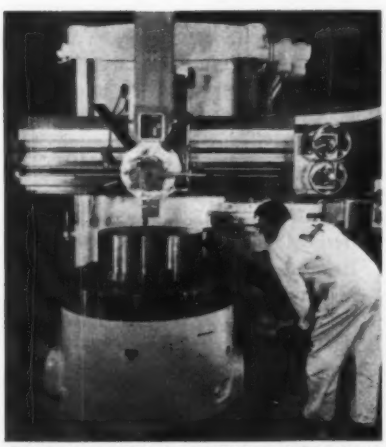

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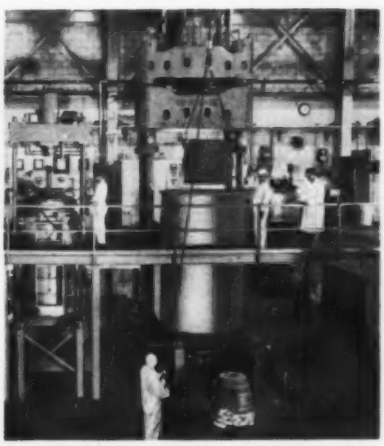

Various shapes and forms of beryllium metal are produced at Berylco by advanced powder metallurgy methods.

1700-ton Loewy hydro press at Berylco's Reading plant extrudes beryllium metal and alloys.

Circle 1669 on Page 48-I

Microstructure . . .

bide in the temperature range between 700 and 1100° F. occurs as epitaxy disks on the (100) planes of the ferrite. These carbides dissolve, and Fe_3C is precipitated after long periods of time. The composition and crystal structure of the intermediate carbide phase is not known.

The results confirm the phase diagram and constitution relationships published by Darken, Hillard and Owen, and Smith. The low-temperature solubility data for carbon agree reasonably well, but leave something to be desired since only one area below the solubility limit was studied. The observations on the kinetics of carbon precipitation are very enlightening, and a correlation with changes in the electrical and magnetic properties would give valuable information to the users of such steels. The precipitation was studied primarily by optical microscopy. It is hoped that studies of the early stages of precipitation will be carried out in the future.

Despite these limitations, this work is a valuable addition to the studies of the structure of steel, and should attract much attention because of the wide use of the 3.25% silicon steel.

R. W. GUARD

Rhenium-Columbium Alloys

Digest of "The Constitution of Rhenium-Columbium Alloys", by P. Levesque, W. R. Bekebrede and H. A. Brown. ● Preprint No. 192, 1960.

THE CONSTITUTION of rhenium-columbium alloys has been investigated throughout the entire composition range. Using arc-melted buttons, conventional techniques of metallography, X-ray diffraction, hardness measurements, and incipient melting were employed. On the columbium end of the diagram there is a wide terminal solution range of rhenium in columbium (beta phase), with solubilties of 40 at.% at 1200° C. and 42.5 at.% at 2350° F. With increasing rhenium content, the lattice parameter decreases and the hardness increases.

In the composition range from 42.5 to 64 at.% rhenium at 2200° C., the researchers noted a two-phase region consisting of the beta phase and a body-centered cubic phase. The latter was designated χ (chi). The chi phase is isomorphous with α-manganese, and is similar in structure to the chi phase found in Fe-Cr-Mo alloys. The boundary lines of the two-phase region extend to the eutectic temperature of 2380° C. The eutectic composition is at 47.5 at.% rhenium, and the terminal compositions at the eutectic temperature are 42.5 and 64 at.% rhenium. This indicated a negligible change in rhenium solubility with temperature.

At about 1075° C., there is a peritectoid reaction at about 50 at.% rhenium, which results in the appearance of a tetragonal phase isomorphous in structure to the sigma phase in Fe-Cr alloys. The sigma phase has a very narrow solubility range.

The chi phase which is very hard and brittle extends as a single-phase region from 64 to 87 at.% rhenium

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MARVEL Metal Cutting SAWS

Circle 1670 on Page 48-E

NEW IDEAS IN COPPER ALLOY ROD AND WIRE

Interesting things happen when you add a spot of zirconium or chromium to copper—four high-conductivity coppers that boost production, cut cost of machining—even plain old free-cutting brass rod is going fancy.

There's a quiet revolution going on in copper metallurgy. Research and development teams are expanding the useful knowledge of copper and copper alloys in an effort to define the properties most suitable for specific engineering applications.

STABILITY at elevated temperature, combined with good electrical conductivity, is probably a combination most sought after by design engineers and by our industry's research teams. Two alloys are now commercially available, and the alloy systems are unique. Chromium copper and zirconium copper are heat-treatable alloys with good stability of mechanical properties up to temperatures in the order of 600 F.

CHROMIUM copper in the fully heat-treated condition following a solution anneal will exhibit properties combining a tensile strength of about 75,000 psi with conductivity of approximately 80% IACS. Zirconium copper has good stability characteristics at elevated temperatures and conductivity of 90 to 95% IACS; the strength properties developed by heat treating are, however, somewhat lower than chromium copper.

SEVERAL other heat-treatable copper alloys with intermediate properties are gaining recognition in the connector and electronics fields. These alloys fall into a conductivity range of 35 to 65% IACS, with tensile strengths 90,000 to 100,000 psi. The most popular alloy systems are the copper-nickel-phosphorus and copper-nickel-silicon series with modifications for free machining or other specific requirements. These alloys have a solution annealing temperature about 100 to 200 C lower than the chromium and zirconium coppers.

THE WIDESPREAD use of panel or harness construction for linking segments of electrical control devices has made the requirement for free-cutting coppers mandatory. Screw machine shops are fabricating these connector components of various designs by the millions. Currently the most popular free-cutting coppers are leaded copper with conductivity of about 98% IACS, and tellurium and sulfur coppers at about 95% IACS. Some of these free-cutting coppers have residual oxygen and can become brittle or gassed under the usual conditions contributing to this phenomenon. All, however, can be obtained with a combination of deoxidizers or oxygen-free copper. In the case of the deoxidized variety, some slight sacrifice in conductivity will be noticed. Ordinary usage very seldom requires conductivity in excess of 90% IACS – and this presents no problem for these coppers.

ALL of these coppers can be cold worked without too much trouble. They can be supplied in a suitable wire temper for cold heading and secondary operations designed around the basic alloy system. Up to now there has not been too much interest in these alloys for wire forming or heading operations. Close dimensional tolerances may be the reason for the reluctance of the heading people to get into the electrical connector business. Alloys are available with the ductility and mechanical properties necessary for this type of forming. It would appear that some of the products could be made more economically by cold-heading or wire-forming operations.

RECENT TRENDS have also affected the old brass and copper reliables. There can't be any product more prosaic than free-cutting brass rod; it is the cheapest of such commodities and at one time was the easiest to process—all one had to do was to extrude, draw to finish dimensions, and ship. In many cases this practice won't work today. Deep drilling, roll threading, knurling, staking, slotting, etc., have complicated the picture, but the latest efforts of the screw machine builders have laid this ghost to rest. We now hear of beta-free rod for close tolerances on deep-drilling applications. Similar grain structures, but not necessarily the same temper, are required for roll threading, knurling and staking or whenever extra ductility is needed. Along with the consideration of grain structure, it has been necessary to take advantage of the broad chemical composition range for free-cutting brass. Most suppliers divide the standard range into two parts, utilizing the lower copper range for the larger sizes that will normally be machined on the heavier, faster screw machines where chip breaking and clearing the tools are the most important considerations. This might be considered the rough, breakdown type of stock.

FOR the smaller diameters, specialization has been the watchword. Depending on specific needs, you can now obtain free-cutting brass rod with all-alpha, fine-grained structure or an alpha-beta fine-grained extruded structure, or possibly a combination of both. For certain applications you might need a coarse-grained, all-alpha structure. Lead dispersion and lead content are other variables that can and will be controlled to meet fabricating or end-use requirements.

IN the cold-heading industry, advantage is being taken of the wider selection of copper and copper alloys that is available today. The nickel silvers, phosphor bronzes, and silicon bronzes combine good ductility and high strength with excellent corrosion resistance. The whole range of common brasses has specific applications and can be tailored to various heading operations.

The research and development hopper is full of interesting new ideas and projects at Anaconda American Brass Co. It could be that we're working on something which would help solve one of your problems. Even though we don't have the complete answer, perhaps we could both reach a solution faster by pooling our efforts. Call your Anaconda representative and talk it over with him or write: Manager, Market Planning, Anaconda American Brass Company, Waterbury 20, Conn.

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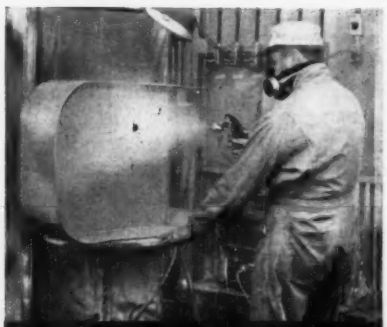

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Circle 1673 on Page 48-B

Re-Cb Alloys . . .

at 2200° C. and decomposes peritectically at about 2720° C. Solubility of columbium in rhenium is estimated to be about 4 at.% at 2720° C. and less than 2 at.% at 2100° C. H. H. CHISWIK

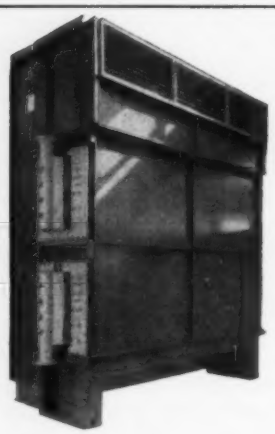
Corrosion of Stainless Steel Welds

Digest of "Preferential Corrosion of Stabilized Stainless Steel Welds", by C. L. Angerman and P. M. Kranzlein. Preprint No. 208, 1960.

THIS PAPER DESCRIBES the results of an electron microscopic study of the corrosion mechanism of Types 309 S Cb, 347 and 321 stainless steel weldments in two mediums: a boiling solution of 17.2% HNO_3 + 0.15% HF, and boiling 65% HNO_3. The welds were made by either metal-arc or heliarc processes; filler rods were either of the same composition as the wrought metal, or were Type 308 L weld rods. For electron microscopic examination, polished and etched specimens of the welds were placed in the solutions for intervals of 10 to 30 min. "Formvar" replicas were cast, stripped, and shadowed with uranium at an angle of 45°. A few 48-hr. tests were made to determine the over-all corrosion rates in these mediums.

In weldments of either Types 309 S Cb, 347, or 321 steel, the weld metal was severely attacked by the boiling HNO_3-HF solution at an estimated rate of 200 to 600 mils per year (mpy). Attack occurred along dendrite grain boundaries. Heating of the Type 309 S Cb weldments to 1065° C. for 30 min. reduced the corrosion rate to 25 to 75 mpy. This reduction in corrosion rate is attributed to a decrease in the continuity of the CbC network along the grain boundaries. Heating at 900° C. did not alter appreciably the rate of attack, even though X-ray diffraction analysis indicated the presence of sigma phase.

The electron microscopic studies after the short-term corrosion tests indicated that the attack (by both mediums) occurred by preferential dissolution of carbides located along the grain boundaries and adjacent to ferrite pools. Carbides attacked dur-



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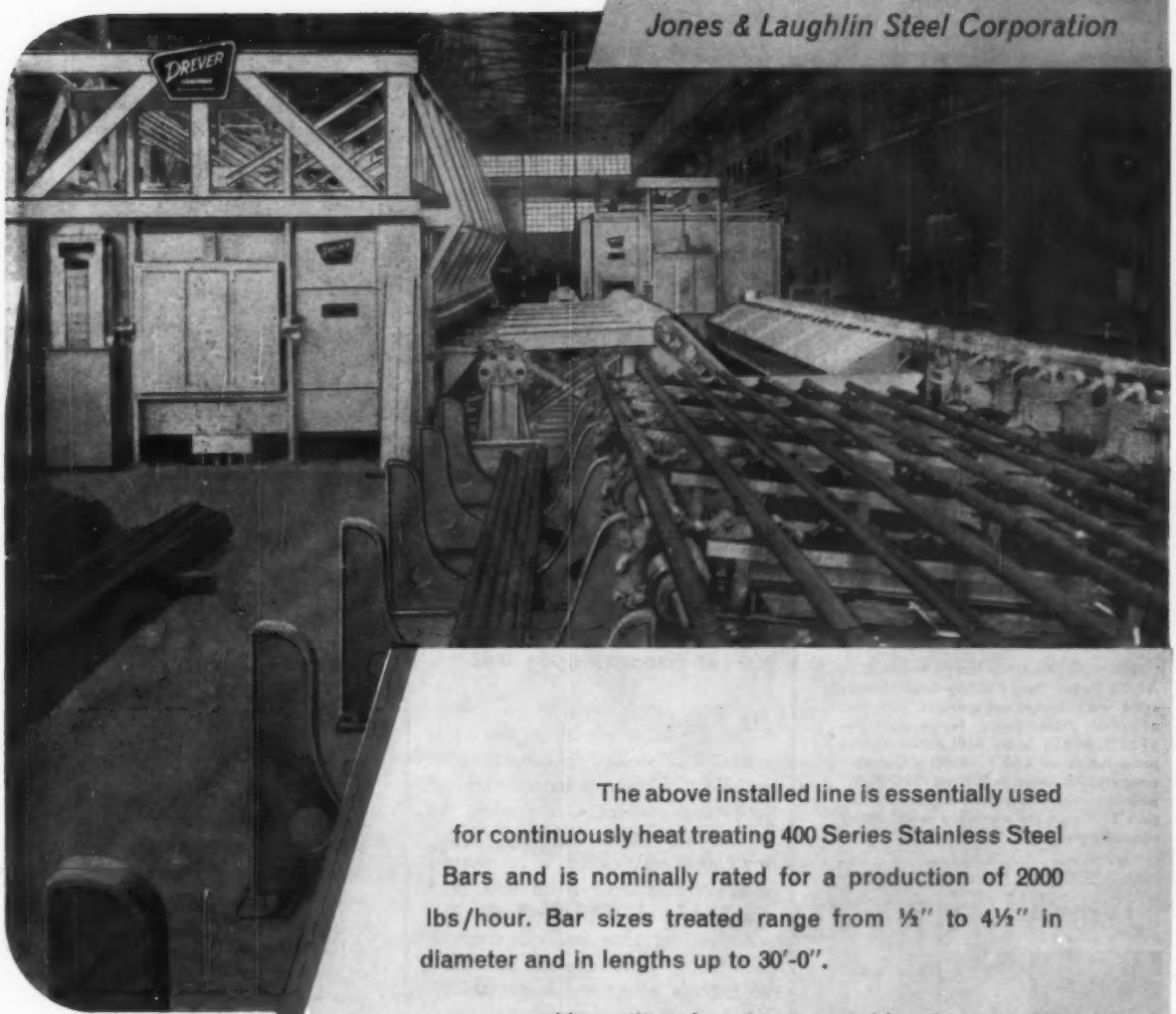

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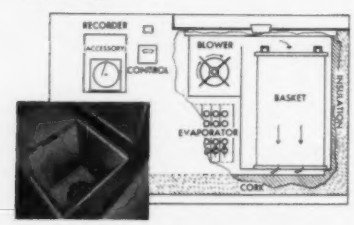

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Circle 1675 on Page 48-B

Stainless Welds . . .

ing corrosion were identified as CbC in Types 309 S Cb and 347, and as TiC in Type 321. For comparison, the mechanism of attack in the same mediums was also examined in a nonstabilized and sensitized Type 304 steel. In this instance, corrosion proceeded by preferential attack of the grain boundaries adjacent to the $Cr_{23}C_6$ particles (that is, in the zone depleted of chromium).

Further evidence in support of the preferential carbide attack mechanism in the stabilized steels was obtained in the examination of the welds in which Type 308 L filler rods were employed. In these welds, a type of attack similar to knifeline attack was noted. Examination revealed a network of carbides that had been formed by incipient fusion of the base metal immediately adjacent to the weld. The base metal and the weld metal which did not contain the network were more corrosion resistant. H. H. CHISWIK

Boron in Steel

Digest of "On the Hardenability Effect of Boron in Steel", by R. A. Grange and J. B. Mitchell. Preprint No. 188, 1960.

MINUTE PERCENTAGES of boron have large effects on the hardenability of steels. The hardenability effect of boron is strongly related to carbon content of the steel, but not to the amount of boron. A boron constituent, called "B", is formed after certain heat treatments, and the amount of "B" is affected by the austenitizing time and temperature. Therefore, to promote understanding of boron's effect on hardenability, the effect of austenitizing treatments on "B" was studied. Steels 8620, 8650 and 8680 were compared with steels 86 B 20, 86 B 50 and 86 B 80 after austenitizing. Boron had no effect on the M_s temperatures and little effect on the grain coarsening temperatures of these steels. As carbon content increased, boron was relatively less effective in retarding transformation to pearlite.

In a particular boron steel, such as 86 B 50, austenitizing followed by isothermal holding at a lower temperature produced progressively greater amounts of "B" with increas-

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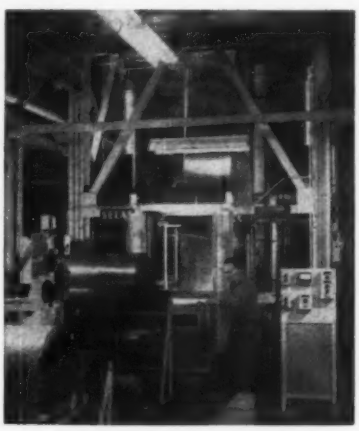

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Circle 1676 on Page 48-B

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Circle 1677 on Page 48-B

Boron in Steel . . .

ing time. Thus "B" is produced by isothermal precipitation. A smooth "C"-shaped curve of temperature plotted against time was obtained for formation of "B" in 86 B 50 steel austenitized at 2200° F. Isothermal precipitation of "B" proceeded with increasing rapidity down to 1400° F., and then progressively more slowly as temperature was decreased from 1400° F. Because "B" did not precipitate in steels austenitized below 1550° F., it was believed that a minimum quantity of boron must be dissolved in austenite to precipitate "B". Increasing carbon content increased the amount and rate of precipitation of "B".

The principal effect of the precipitation of boron constituent "B" is to deplete austenite of boron atoms. Boron's loss of effectiveness after high austenitizing temperatures is attributed to precipitation of "B" during the earliest stages of transformation. Boron is most effective toward increasing hardenability if "B" precipitates at the time when the austenite is transforming to ferrite and carbide. The time when this precipitation takes place is controlled largely by the austenitizing temperature. Thus, boron's effect on hardenability depends upon the interaction of four factors: (*a*) effective boron content, (*b*) carbon content, (*c*) alloy content, and (*d*) austenite grain coarsening behavior. There appears to be an optimum percentage of dissolved boron for maximum hardenability.

Commercial boron steels often contain more boron than will dissolve in the normal austenitizing range, 1500 to 1700° F. Hot work experiments indicate that boron is distributed uniformly in the austenite. Then, as the austenite cools from the austenitizing temperature, boron atoms migrate to the grain boundaries. DAVID KRASHES

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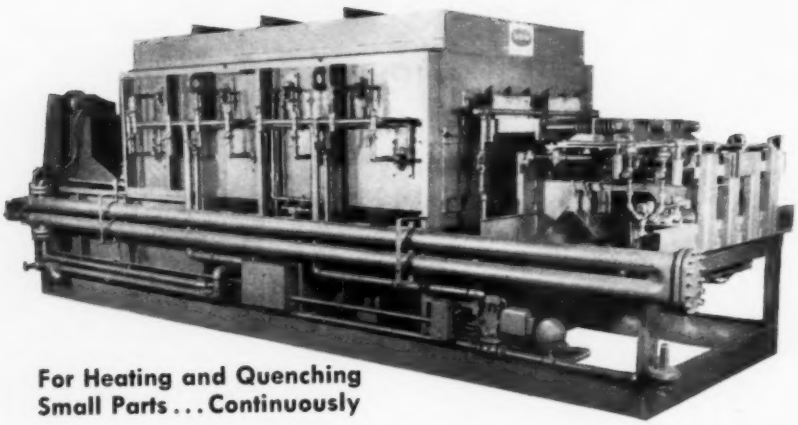

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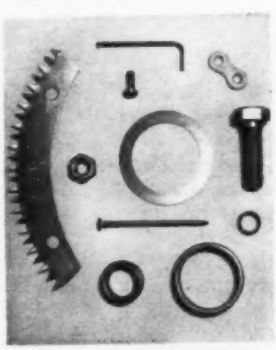

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Circle 1678 on Page 48-E

Austenite Decomposition

Digest of "The Decomposition of Austenite in 4340 Steel During Cooling", by E. P. Klier and T. H. Yeh. Preprint No. 183, 1960.

AN EARLIER PUBLICATION by one of the authors, E. P. Klier, showed that the hardenability of A.I.S.I. 4340 steel could be increased by cooling slowly through the critical range before quenching. In the present work, this phenomenon was studied by using hardenability testing, and by determining the isothermal and cooling transformation diagrams for several heats of 4340 steel.

A preliminary study was made, using the standard end-quench hardenability bar, to determine if an austenitizing treatment (such as 1500° F.) could be followed by a low-temperature (1350° F.) stabilizing treatment to develop a hardenability increase. Increased hardenability was observed if the bars were held for 1 or 4 hr. at 1350° F. (about 25 to 50° F. below the Ae_1 temperature) in place of quenching directly. However, the hardenability of the steel is such that only a little improvement is shown by this test.

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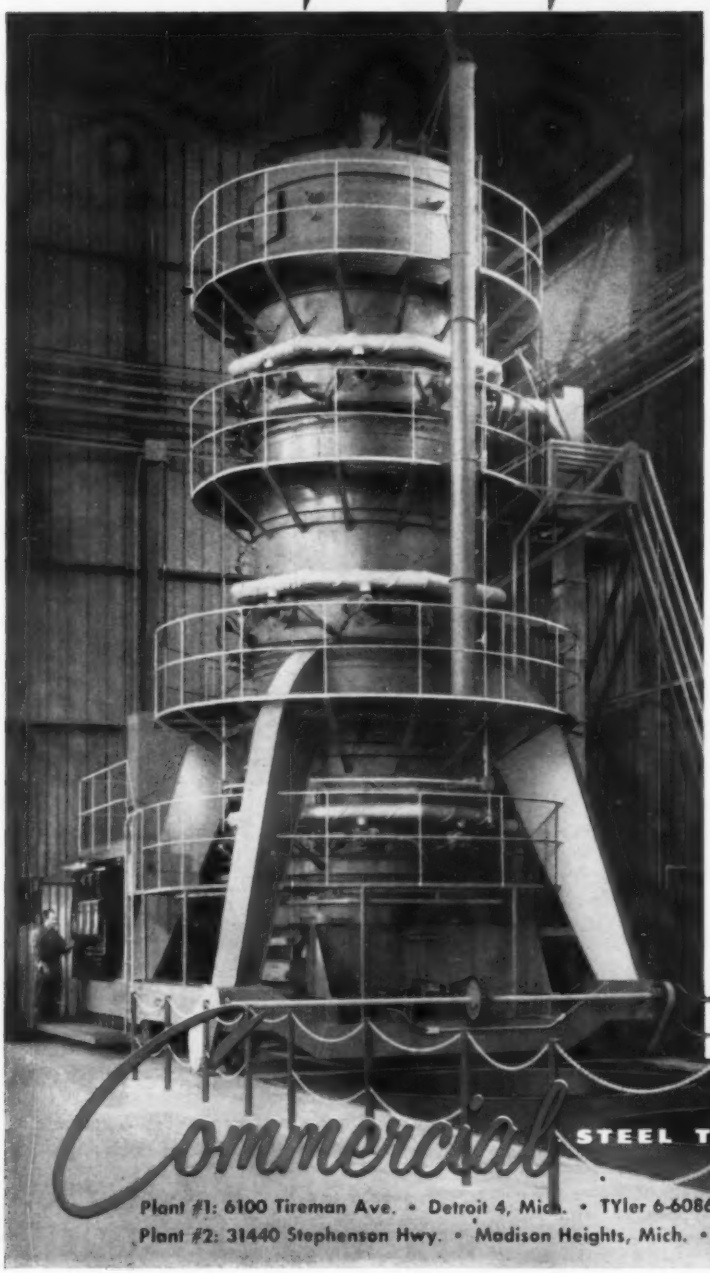

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Circle 1679 on Page 48-B

Austenite . . .

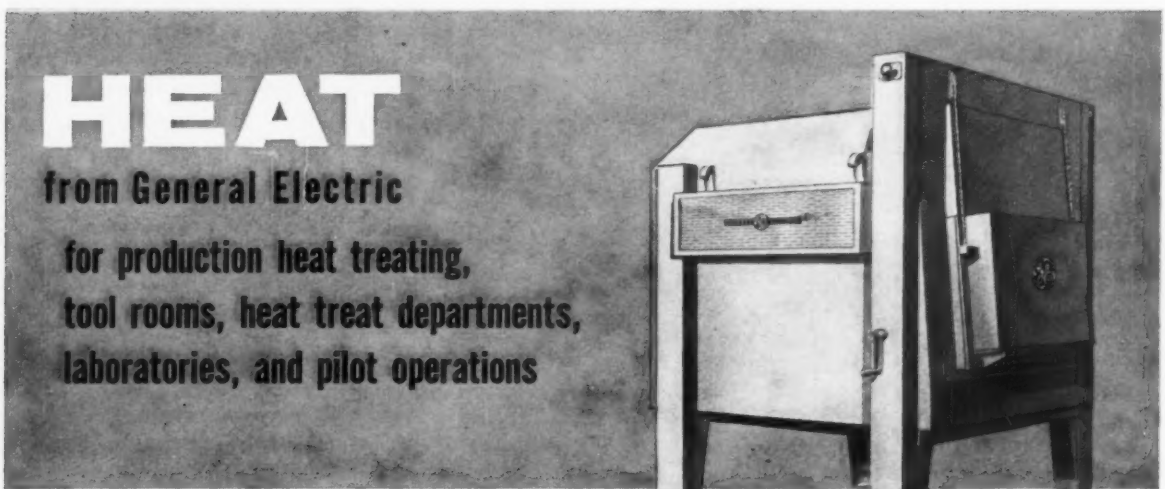
bar (2.5 in. diameter by 7.75 in. in length) was then used to provide a more severe hardenability test. In a number of comparative tests, two bars were austenitized similarly: One was quenched directly whereas the other was first cooled to 1350° F. in 1 hr. and then quenched. The "stepped" treatment (1350° F. hold) markedly increased the hardenability for low-temperature austenitizing, such as 1500° F. The stabilizing effect of holding at 1350° F. diminishes gradually as the austenitizing temperature increases, becoming very small at 1550° F. and disappearing entirely for a 1600° F. austenitize.

To emphasize that the "stepped" heat treating cycle could be of importance in commercial heat treating, two series of variable diameter bars were quenched from 1500° F., one series in water and one in oil. The oil-quenched bars developed substantially higher hardness (as much as ten points Rockwell C) than the water-quenched bars. Presumably, austenite stabilization was associated with the slower cooling characteristic of oil quenching. Possibly this stabilizing phenomenon may account for some of the unexplained observations in commercial heat treating.

Isothermal and cooling transformation studies of the 4340 austenite were made to throw more light on the stabilizing phenomenon. The results indicate that ferrite formation minimizes hardenability in the treatment comprising low-temperature austenitizing (1500 to 1550° F.) followed by direct quenching. In the "stepped" treatment (1350° F. hold) the austenite is stabilized, ferrite does not form, and thus hardenability is improved. Apparently the "stepped" treatment has little, if any, effect on bainite transformation; however, the M_s temperature may be lowered in some instances.

In summary, the authors point out that the hardenability of steel is complex and, contrary to the commonly accepted belief, the depth of hardening does not always increase with an increase in cooling rate. Under some austenitizing conditions, hardenability actually may decrease as cooling rate increases. The observed decrease in hardenability in 4340 steel was caused by ferrite formation during rapid cooling from low austenitizing temperatures (1500 to 1550° F.). If cooling rate was decreased or if cooling was arrested at 1350° F., the austenite was stabilized with respect to ferrite formation, and the austenite then transformed to bainite and martensite at lower temperatures. The degree of stability depends on austenitizing temperature; it is large for 1500° F., significant for 1550° F., and nil for 1600° F. and higher temperatures.

O. O. MILLER



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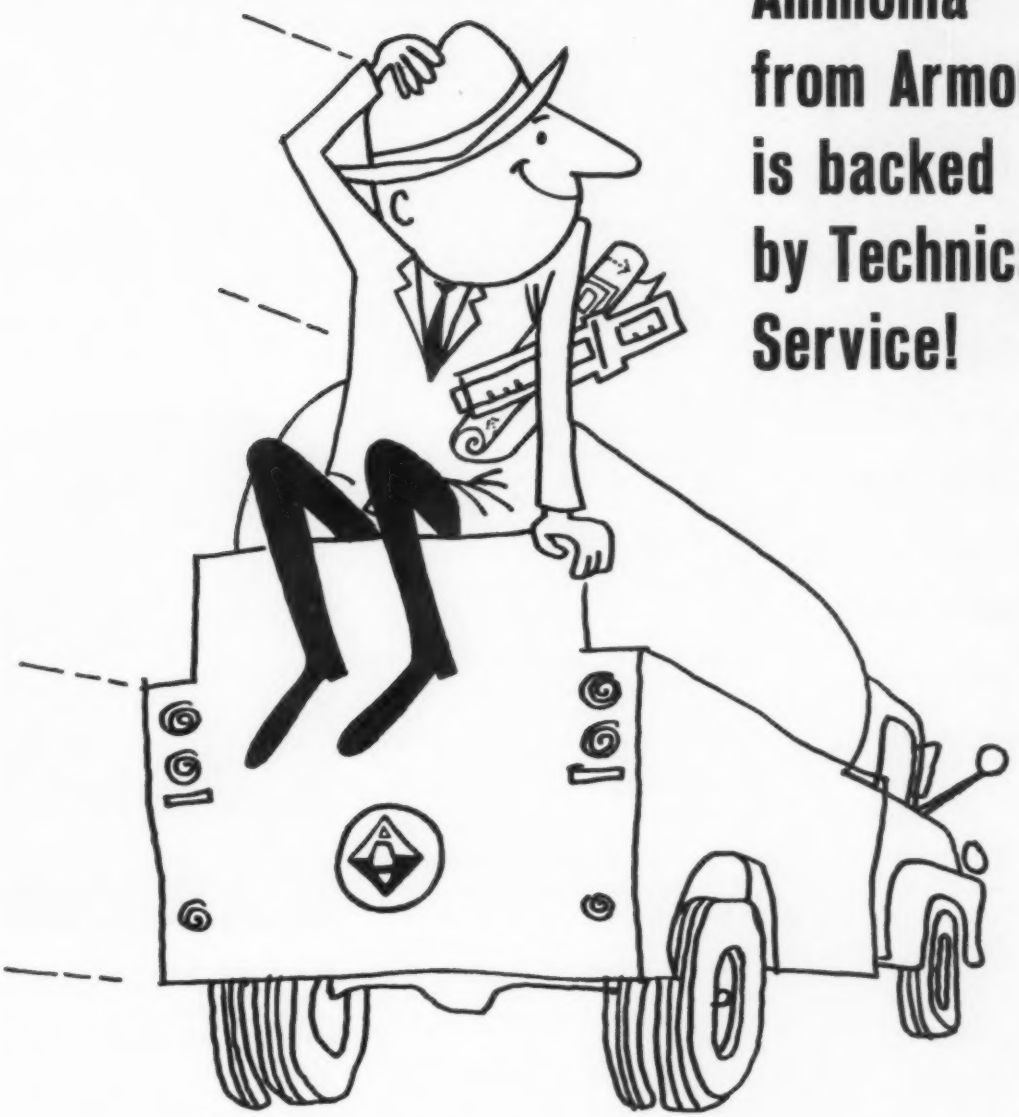

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The Road Ahead for Metals

Reported by W. W. AUSTIN*

At the Southern Metals Congress, held recently in Birmingham, Ala., the all-embracing question "What lies ahead for metals?" was answered by 13 speakers. Three main topics – basic metallurgy, production developments, and processing methods – were covered.

AT THE THIRTEENTH annual Southern Metals Conference in Birmingham, Ala., 13 speakers presented an array of papers on the theme, "Metallurgy and the Road Ahead", covering three general areas: basic metallurgy, metallurgical developments for production, and fabrication and processing methods. In the keynote address, R. J. Raudebaugh, International Nickel Co., emphasized that metallurgy today is the product of many outstanding contributions. Among the more important of these, he said, are the newer techniques for controlling purity down to the parts per million range. Because of this work, the transistor field has grown very rapidly. This research is also responsible for the improvements in ductility and workability recently achieved in such metals as titanium, molybdenum and tungsten. In the realm of solid-state physics, better understanding of the role of lattice imperfections in determining properties has resulted in the so-called "engineered solids". (Ferrites and ductile ceramics are two examples.)

Turning to nuclear power, D. W. Lillie, General Electric Co., reviewed 15 years of developments in nuclear materials. High on this list are the zirconium and zirconium alloys (new structural materials), uranium oxide (a fuel material), and the present trend toward high-temperature gas-cooled reactors.

Many unsolved problems still plague the nuclear metallurgists, however. Here are a few of them: radiation damage and the inherent dimensional instability of uranium metal, the complex and perplexing metallurgy of thorium and plutonium and their alloys, the lack of ductility and workability in beryllium, the catastrophic corrosive attack of water on aluminum alloys above 350° C. (660° F.), and the severe embrittlement of zirconium alloys by traces of hydrogen.

As for the road ahead in power generation, reference was made to important work on thermo-electric and thermionic effects as adjuncts to nuclear reactors for direct conversion to electric power. Also mentioned was the controlled thermonuclear (fusion) process employing deuterium and tritium, in which tremendous quantities of power may be generated from an almost limitless supply of cheap raw material—water.

The science and art of metallography are advancing rapidly, according to R. J. Gray, Oak Ridge National Laboratories, who discussed recent achievements in this field. The metallographer, he states, is now freed from the drudgery of manual polishing and specimen preparation, and can devote his time to developing new techniques and to other work. As a result, a number of new and highly useful contributions of metallography have appeared in recent years. Among these are chemical and vibratory polishing, vacuum cathode etching, magnetic etching,

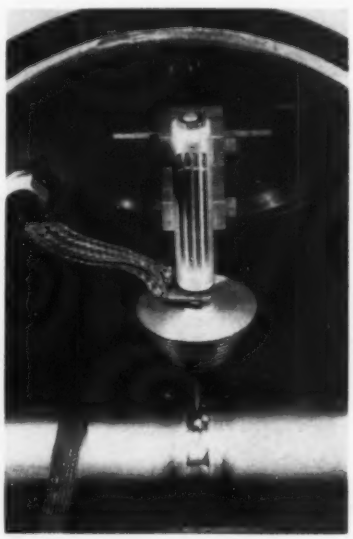

Fig. 1 – Zircaloy-2 Tubing Is Being Welded in an Inert Atmosphere With This Setup. (Courtesy Allegheny-Ludlum Steel Corp.)

*Head, Dept. of Mineral Industries, North Carolina State College, Raleigh, N.C., member, *Metal Progress* Advisory Committee.

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Circle 1685 on Page 48-B

Metals . . .

and substantial improvements in the techniques of replication for electron microscopy.

Looking ahead, he predicted that one of the most useful items of new equipment in this field will be the microprobe analyzer. This tool can quantitatively analyze elements of atomic number eleven and higher in areas as small as one micron in diameter. The essential feature of this instrument is a very fine and precisely collimated electron beam which scans the area to be examined. Generated by this electron beam are X-rays which are continuously correlated with the known characteristics of the various elements.

As for other techniques, noteworthy in the atomic field are the shielded and sealed remote metallograph, along with the use of chemical staining, heat tinting, and weak anodizing to study and identify unusual structures and microconstituents. The metallography of uranium and its compounds, the study of hydrides in zirconium, and of deformation bands in yttrium were cited as typical examples of this work.

Production Related to Steel

"The road ahead for production is integrally related to the steel industry", stated O. T. Marzke, United States Steel Corp., who reviewed the steel production picture. In discussing the future, quality requirements and improvements in efficiency and operating costs were covered. Though steel production capacity in this country today is over 148 million tons, representing an increase of 50% in the last decade, the next ten years are unlikely to see a comparable growth. At this point, forecasters are predicting a 2 to 3% increase in production capacity.

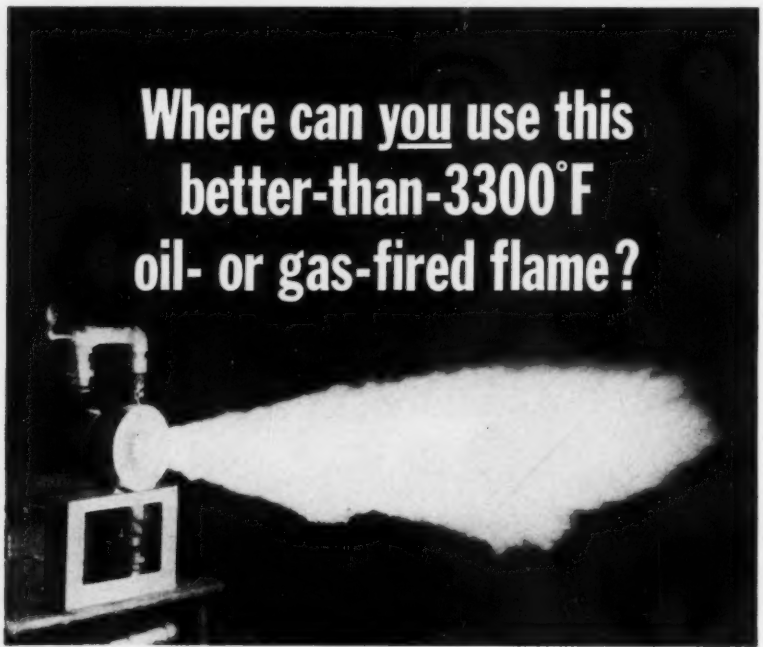
In terms of properties, it is much more certain that the future will lead to more and more severe requirements both as to quality and performance. Though use of steel in space-age applications is but a minute fraction of the total, specifications are quite rigid. (However, they must be met because the need is critical.)

Engineers of spacecraft are notorious for their idealistic demands. To them, an ideal metal would have tensile strength and elastic modulus at least *twice* that of any known alloy. It would also be ductile, corrosion resistant and of low density — and it would retain these properties to 5000° F. or higher. Furthermore, the alloy would be readily available at low cost. Although steel producers say these demands are unrealistic, they do admit that they provide an excellent aim for research.

In other areas, steel metallurgists are now exploring improved raw materials and smelting practices, new steelmaking processes, low-cost oxygen, and better refractories. Continuous processes with better and closer controls over quality and uniformity are also being researched as are ways to increase strength (even beyond that of present ultra-high-strength steels) while maintaining good heat and corrosion resistance.

"Light metals will undoubtedly continue to play an important role", said G. F. Kappelt, Bell Aircraft Corp., in emphasizing the need for applying the materials engineering concept. He reviewed the current status and the future outlook for

Where can you use this better-than-3300°F oil- or gas-fired flame?



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produces temperatures never before achieved with oil or natural gas. Burning oil, it can reach a searing 3450°F. On 1000 BTU/cu. ft. natural gas, it develops 3320°F. Both these extremely high temperatures are close to the theoretical limits for these two fuels. Foundries, smelters, heat treaters and other metal processers have been quick to take advantage of the remarkable combustion efficiency of these new burners. To them, it has meant faster heating cycles, cleaner flue gases, and above all, fuel economy that cuts from 12% to 30% from their furnace overhead. Not to speak of reduced maintenance on refractory linings.

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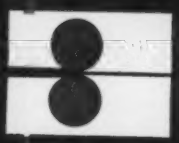

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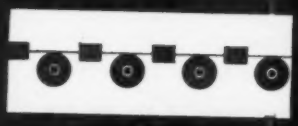

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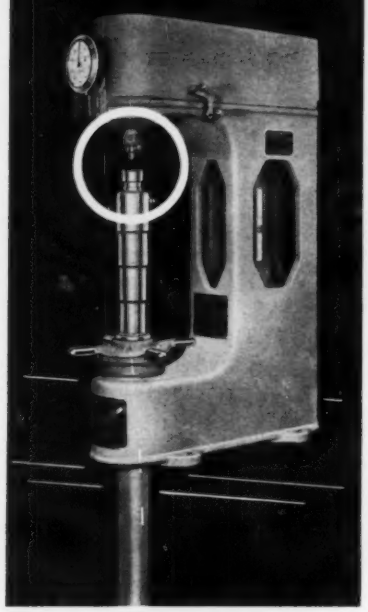

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Missile-Age Accuracy

Circle 1688 on Page 48-B

Metals . . .

alloys of aluminum, beryllium, magnesium and titanium. Aluminum, traditionally the leader among light metals, is getting renewed attention in efforts to further improve strength, and resistance to corrosion and heat Here, outstanding results are being reported from research on vacuum die castings. Alloys 7075 and 2024 can now be die cast with properties approaching those of wrought products. Another significant achievement has been the introduction of X 2020 alloy. Containing 1% Li, 0.55% Mn, 4.5% Cu and 0.2% Cd, it has good room-temperature properties, and is usable up to 500° F. (and above in some applications).

Beryllium and its alloys are used only slightly today, major obstacles – toxicity, excessive production costs, and poor fabricability – having hindered widespread acceptance. Recently published results have shown that pure beryllium, produced by electron beam zone refinement, is capable of 40,000 psi. ultimate tensile strength, while powder metallurgy techniques, similar to those used on SAP (sintered aluminum powder) yield 70,000 to 120,000 psi. tensile strength. Greatest need for beryllium today, aside from cost

Fig. 2 – Finned Tube Made by Impact Extrusion of Aluminum Powder. Other parts made by the same method are on the table. (Courtesy Aluminum Co. of America)

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Circle 1689 on Page 48-B

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Circle 1690 on Page 48-B

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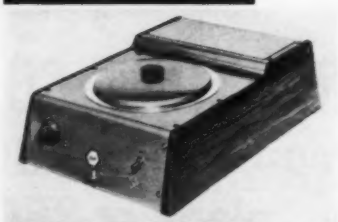

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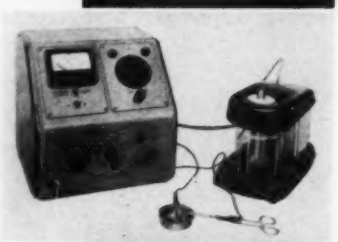

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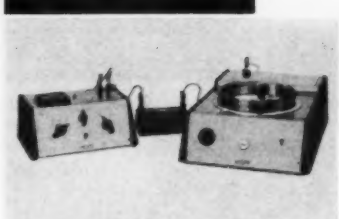

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Circle 1691 on Page 48-B

Metals . . .

reduction, is better ductility and formability.

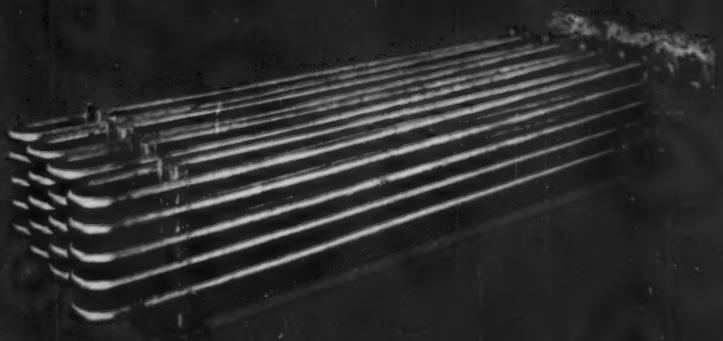
Titanium Costly to Develop

According to the speaker, more money has been spent on the initial development of titanium than on any other similar metallurgical development in history. As a consequence, titanium and its alloys have already received limited acceptance, and they will probably find a natural place in the over-all picture. Current titanium production is limited primarily to the commercially pure metal, the alpha alloy 6 Al, 4 V alloy and, to a smaller extent, some of the beta alloys. Although the 6 Al, 4 V alloy offers tensile strength on the order of 200,000 psi., it cannot be welded satisfactorily. The beta alloys appear to weld better, but have lower strength and are not yet in large-scale production. As for heat resistance, though titanium alloys are not suited to long terms above 1000° F., they are satisfactory up to 2000° F. for as much as 5 min. Further, tests at 2500° F. show that titanium may prove satisfactory where time at operating temperatures is but 1 to 2 min.

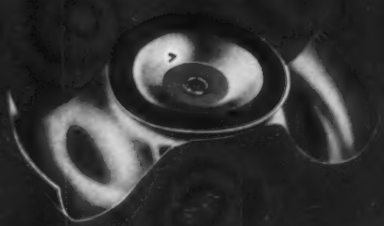
The road ahead for the refractory metals looks bright indeed, according to Joseph Maltz of the Bureau of Naval Weapons. Comprised of representative elements from two subgroups of the periodic table (tantalum, columbium and vanadium from Group V-A, and chromium, molybdenum and tungsten from Group VI-A), all refractory metals have melting points in excess of 3000° F. Members of the Group V-A possess somewhat lower melting points and lower strengths, but are more easily fabricated than the VI-A metals. The latter group is characterized by higher elastic moduli and high strength, but it has poor ductility at room temperature. Hydrogen, oxygen and nitrogen cause severe embrittlement when they are present in more than a few parts per million. Recently, interstitials in molybdenum have been lowered to a point where good room-temperature ductility is obtainable. Embrittlement and high tension temperatures are critical with other refractory metals.

Another severe drawback has been poor resistance to oxidation.

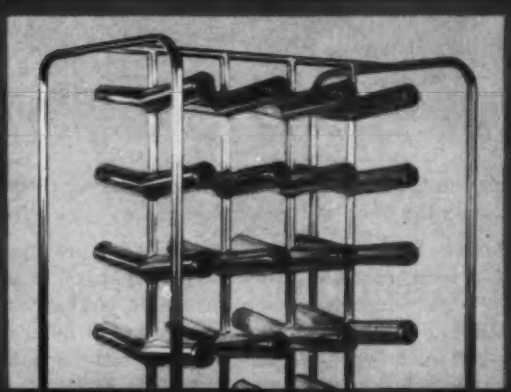
you can bend it...



you can form it...



you can weld it...



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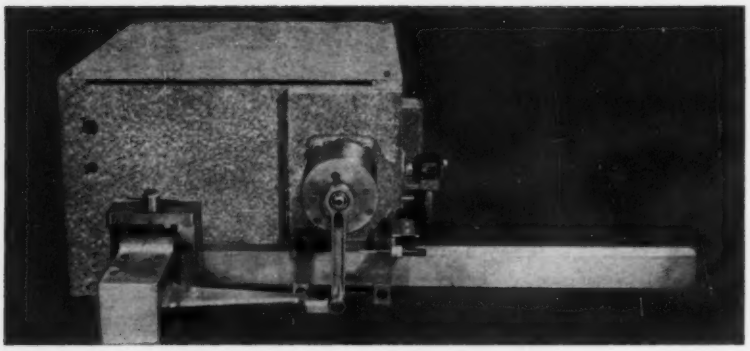
Circle 1692 on Page 48-B



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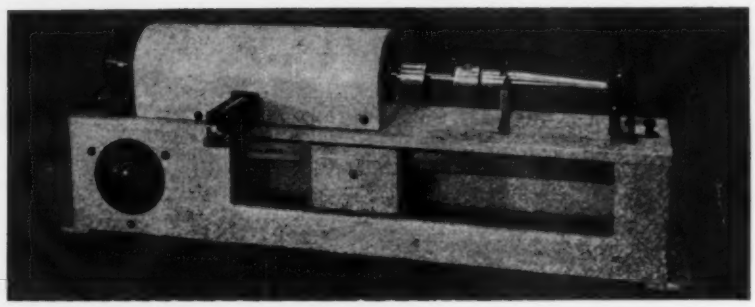

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Circle 1693 on Page 48-B

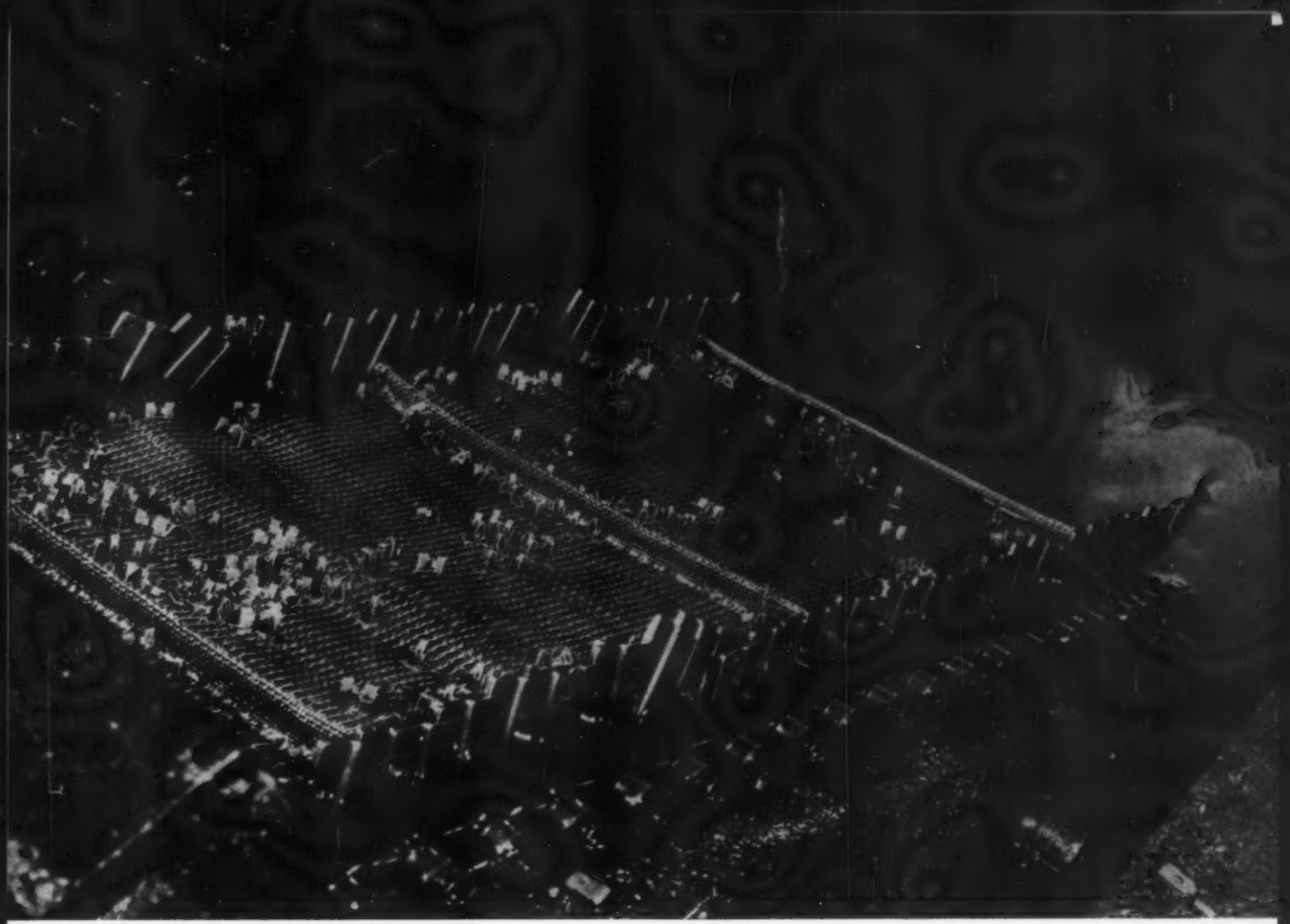
Metals . . .

At elevated temperatures, vanadium forms a low-melting oxide, columbium and tantalum oxide form a loosely adhering scale, and the oxides of molybdenum and tungsten are volatile. Much recent research on this problem has resulted in significant new alloys and coatings of various types. Outstanding among these are the molybdenum-titanium alloys, the tantalum-tungsten alloys, and the success of ordinary hot dip or electrolytic galvanizing as a protective coating on columbium and other refractory metals. To elaborate, not only does the galvanized zinc coating protect against oxidation up to 2000° F., but it is self-healing and will protect adequately even when scratched or damaged over appreciable areas.

It appears that the most promising areas for new achievements will be in purification and melting with vacuum arc and electron beam furnaces, alloy development along the lines of the tantalum-tungsten or the molybdenum-titanium alloys (including dispersion hardened alloys employing such materials as ZrO_2 and TiO_2 as the dispersion phases), and improved fabrication techniques such as the inert atmosphere hot rolling and working (In-Fab) facility described in *Metal Progress*, June 1960, p. 67.

Steady progress in the field of metal castings, according to H. C. Aufderhaar, Union Carbide Metals Co., has made that industry the fifth largest in the nation. Ferrous foundries, which form the major segment of the industry, produce some 16 million tons of castings per year. Gray cast iron accounts for approximately 13 million tons, with malleable, ductile or nodular iron, and steel, including stainless steel, producing one-half million to one million tons each. For the future, new developments in casting techniques and improved properties are expected to result in substantial expansion of all these figures.

Typical of recent achievements has been the acceptance of spheroidal graphite cast iron, also known as ductile or nodular iron. Introduced in 1948 by the British, this new material is now being produced at the rate of some 200,000 tons per year. Recently, a plunging technique for adding the magnesium-bearing nod-



Cuyahoga Products reports:

"We get uniform hardness without distortion on small parts using Gulf Super-Quench®"

K. R. Wilson, left, Heat Treating Foreman, shows Tom Irving, Gulf Sales Engineer, some tiny spring clips. Millions of these clips are produced for industrial customers.

Cuyahoga Products Corporation, Cleveland, Ohio, is a manufacturer of small steel parts such as springs, clips and fasteners. Stock is AISI 1060 or 1070—ranging in thickness from .015 to .035 inches.

"Quenching is the most critical part of our heat treating operation," says K. R. Wilson, Heat Treating Foreman, "because we produce to rigid customer specifications. All parts *must* be uniformly hard without cracking or distortion, or they're rejected. Four years ago, we started using Gulf Super-Quench. Since then, we've never had any trouble getting a uniform 58 to 60 Rockwell C hardness on these tiny parts. What's more, we've practically eliminated rejections."

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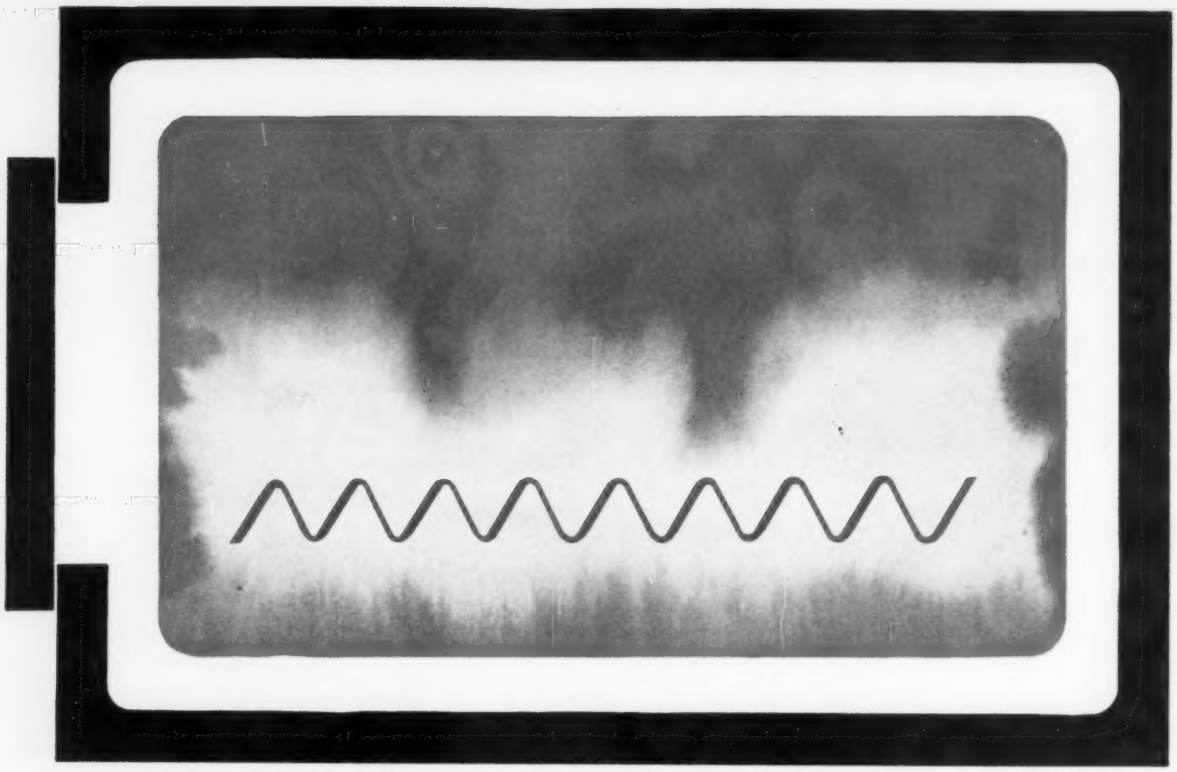

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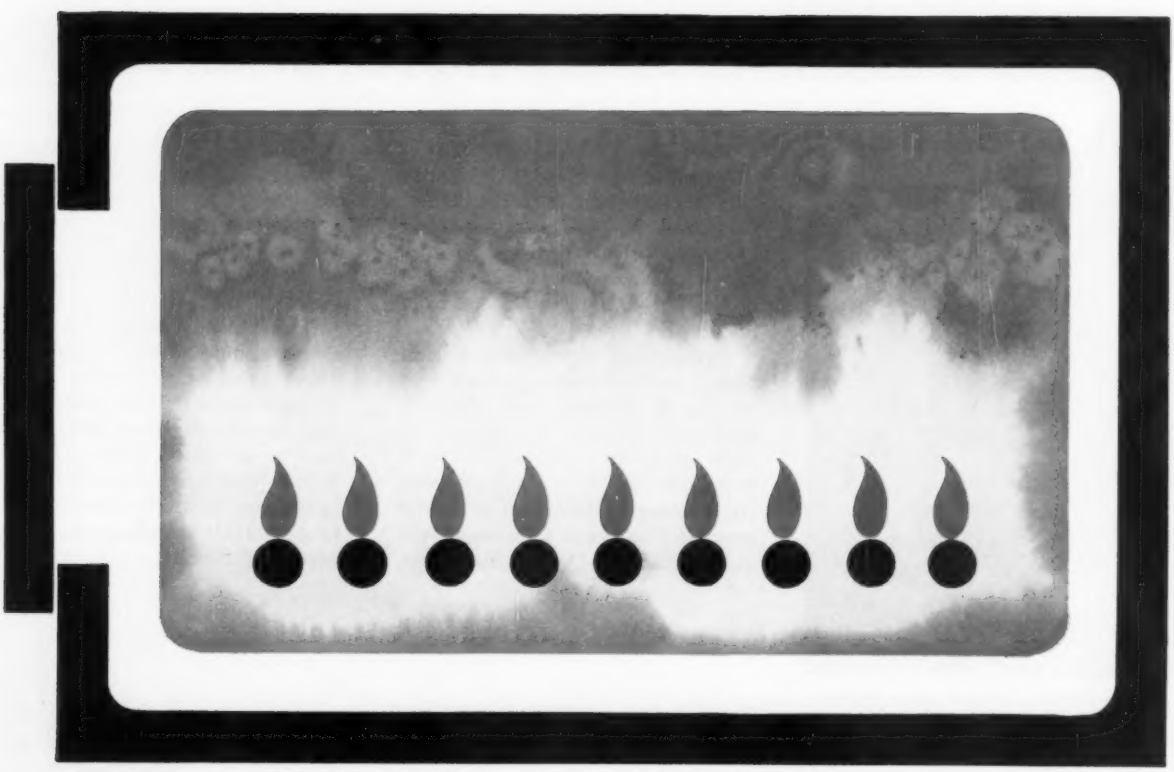

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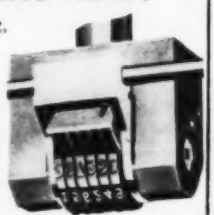

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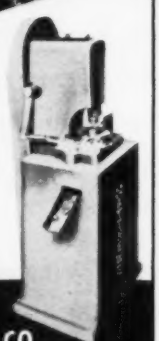

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Circle 1696 on Page 48-B

Metals . . .

ulizing agent to the molten iron has done much to improve the heretofore erratic recovery of magnesium and the resulting nonuniformity and unpredictability of properties.

Foundries can now cast A.I.S.I. 4330 steel with tensile strength approaching 300,000 psi. and with 4 to 5% elongation. Future research is expected to enhance these figures. Cast stainless steels have also received attention, and application of the precipitation hardenable grades produced by vacuum techniques will highlight the road ahead.

An account of vacuum technology was presented by J. D. Nisbet, Allvac Metals Corp. Today, the annual production capacity is 150,000,000 lb., exclusive of vacuum degassing.

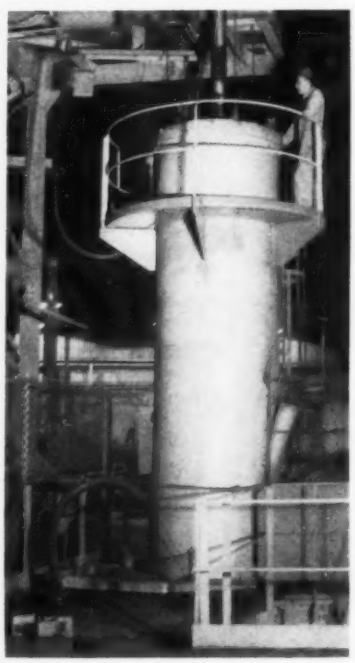


Fig. 3 – A Worker Checks Alignment of Electrode in Consumable Electrode Vacuum Melting Furnace. (Courtesy United States Steel Corp.)

The growth curve of vacuum melting from 1950 to 1960 parallels that for electric steel production from 1905 to 1915, and it is expected that by 1970 1% of all metals produced will be vacuum melted.

Vacuum production processes may be grouped in four classes: vacuum degassing, consumable arc melting, induction melting, and electron beam processes. Of these, vacuum degassing is now widely used in the steel industry for reducing hydrogen. Time saved by eliminating heat treatments formerly used for this purpose has made the vacuum process highly profitable. Consumable arc melting is chiefly applied to the handling of reactive metals such as titanium or zirconium where atmosphere control and avoidance of contamination are essential. Induction vacuum melting now accounts for 50,000,000 lb. of production per year. It has the decided advantage of almost complete flexibility in the control of raw materials. The electron beam process, newest and most precise vacuum technique, enables almost complete elimination of all contaminants. However, the need for extremely high vacuums and very small capacity (measured in grams) limits the process to materials valued at $50.00 per lb. or over. To sum up, with constantly increasing demands for higher purity and closer control of composition, the future of vacuum metallurgy seems well assured.

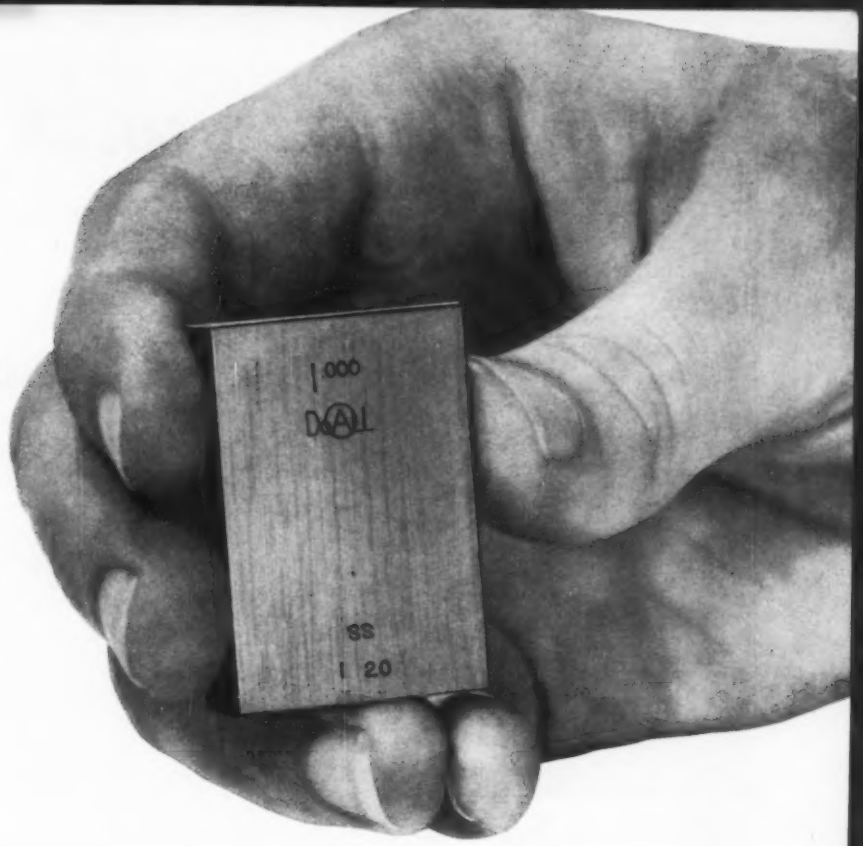
Advances in Welding

Welding advances were discussed by A. R. Lytle, Linde Co., who spoke of some of the current welding problems that have resulted from the introduction of new structural material. Modern welding research is delving into the fundamental relationships between microstructure and control of properties. Also being studied are flux-metal reactions, oxidation and deoxidation of weld metal, and gas-metal reactions occurring during weld deposition.

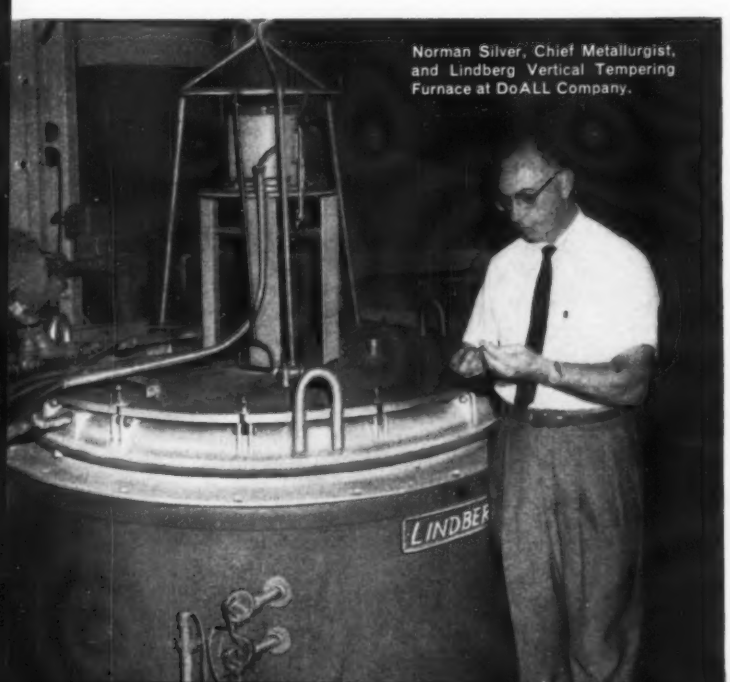
Three developments may be of great potential to the future of welding. Ultrasonic processes have already been perfected for the joining of many metals in foil or sheet form. Electron beam welding holds much promise for the welding of highly reactive or other difficult-to-weld metals. The plasma arc is already in the forefront of research for welding refractory metals and other high-temperature alloys.

Among the problems of the future will be the perfection of welding procedures for the ultra-high-strength steels – steels having 300,000 to 400,000 psi. tensile strength. Each new alloy immediately challenges the welding industry to devise ways and means of joining it without im-

DoALL tells how Lindberg equipment helps produce stainless steel gage blocks



For the DoALL Company, Des Plaines, Illinois, heat treatment of their Stainless Steel Gage Blocks was a most formidable problem. For lasting accuracy these blocks require extremely hard, wear-resistant surfaces, free from growth or shrinkage, as provided by nitrided stainless steel. Case depth must be controlled accurately and the core maintained at full toughness free of stresses. DoALL found the answer to this problem with a Lindberg Gas Fired Vertical Cyclone Tempering Furnace with a Nitriding Retort.



Norman Silver, Chief Metallurgist, and Lindberg Vertical Tempering Furnace at DoALL Company.

NORMAN SILVER, Chief Metallurgist says, "Our Lindberg equipment supplies the uniformity of heat distribution and the fast accurate control that is needed for the exacting requirements of our product. The furnace responds to control almost instantaneously and maintains the temperature within plus or minus 5°. Its 38" diameter by 36" depth handles 200 to 300 pound loads for the desired production. Results obtained have satisfied us completely with this, the latest of our Lindberg furnaces".

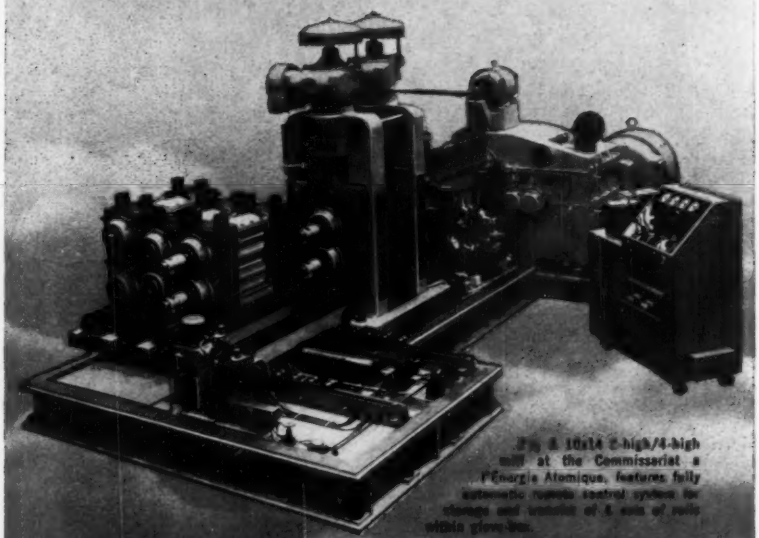
Lindberg provides the most complete line of heat treating furnaces, fuel fired or electric, large or small, for every heat treating requirement. Your Lindberg Field Representative (see your local classified directory) will be glad to consult with you on your heat treating requirements or write us direct. Heat Treating Furnace Division, Lindberg Engineering Company, 2448 West Hubbard Street, Chicago 12, Illinois.

Los Angeles plant: 11937 S. Regentview Avenue, Downey, California. In Canada: Birlefco-Lindberg Ltd., 15 Pelham Ave., Toronto 9, Ont. Also, Lindberg plants in Argentina, Australia, England, France, Italy, Japan, South Africa, Spain, Switzerland and West Germany.

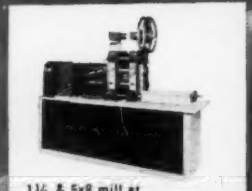
Circle 1697 on Page 48-B

LINDBERG heat for industry

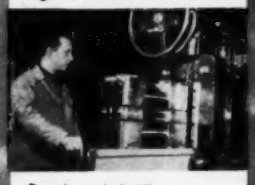
STANAT NUCLEAR MILLS



2½ & 10x14 2-high/4-high mill at the Commissariat a l'Energie Atomique, features fully automatic rundown control system for closure and variation of 4 axis of rolls within glove-box.



1½ & 5x8 mill at Argonne National Laboratories.



Remote control roll removal mechanism for glove-box operation.

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Circle 1698 on Page 48-B

Metals . . .

pairing its inherent properties and characteristics.

The new "In-Fab" installation at Universal-Cyclops was described by H. M. McCullough of that company. Constructed for processing refractory metals, it consists of an argon-filled room which will contain vacuum melting equipment, reheating furnaces which can heat ingots to 3000 to 5000° F. for hot working, a rolling mill, a horizontal forging press (or "Impactor"), and hot shears.

For the final paper, C. H. Sample, International Nickel Co., talked on surface treatment and corrosion. Among recent developments are the extended use of vapor deposition and vacuum evaporation to produce very thin metallic films on almost any surface, and the electroless process used primarily for plating nickel on steel. Advantages of the latter include ability to coat the inner surfaces of pipes and hollow objects, and freedom from many of the limitations of conventional electrodeposition. Another chemically reduced metallic coating (known as "Niphos") is a nickel-phosphorus alloy coating produced by thermal reduction of nickel oxide and sodium dihydrogen phosphate (NaH_2PO_4) in contact with the surface to be coated. A modification of this process produces a wear resistant coating which contains tungsten carbide in a matrix of nickel phosphide.

In the coatings field, there is much promise of improving the appearance, utility, and the performance of many materials having good properties and availability, but which have limited service life (due to poor corrosion or oxidation resistance). Coatings also may solve many of the thermal barrier problems of rockets, missiles and space vehicles.

In conclusion, metals and metals engineers are being challenged today as never before. Each new engineering achievement presents new problems. Knowledge and technical data are being accumulated at such an unprecedented rate that the mere classification and communication of it has become a major undertaking. In truth, metallurgical horizons are unlimited. The road ahead will constantly present new challenges to test the mettle of present and future generations of metallurgists.

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Circle 1699 on Page 48-B

Chain Mail

Digest of "Methods of Making Chain Mail (14th to 18th Centuries): a Metallographic Note", by Cyril Stanley Smith, *Technology and Culture*, Vol. 1, Winter, 1959, p. 60-67.

SIXTEEN PIECES of chain mail of German, Turkish and Persian manufacture (15th to 17th century) were given micrographical and microhardness examination. Usually, chain mail is built up of alternate rows of solid and riveted rings. Though some authorities are of the opinion that the solid rings were made by punching or cutting circles from sheet metal (this would require punches and dies far more precise than those available then), metallography now shows them to be made of two or three complete turns of flattened "wire" welded together.

The riveted links are single loops of larger "wire" with flattened overlapping ends, the rivet holes being drifted with a tapered punch. Rivets are short pieces of carbon-free iron, rectangular in cross section, not tapered, and often bent over at both ends and welded down flat.

Nearly all of the links are of iron with negligible carbon. The steel links (0.15 to 0.60% C) are of steel sheet – there is no sign that they were case hardened.

Evidence is that the "wire" is a narrow strip cut from a flat sheet, often filed, scraped or otherwise abraded into a rounded or semicircular cross section. Many of the links show no sign of further work, as would result from drawing through a die. Professor Smith rejects the contention that the presence of mail in any civilization proves that the knowledge of wiredrawing was in existence at that time.

To quote him, "Though drawing is today the easy and obvious way of making wire, this has not always been so. The making of iron wire by slitting certainly persisted after, and probably preceded by many centuries, the introduction of drawing through dies. Iron is relatively hard, and primitive iron contains slag and scale which quickly destroy any but the hardest die materials, yet it is easy to hammer out a flat sheet and relatively easy to produce sharp cutting surfaces for shears. The presence of longitudinal markings on wire which are often taken as die scratches may be streaks of slag or laminations in the sheet from which the wire was slit.

"These links display regional differences in technique and quality but no evidence of a consistent improvement in metallurgical practice over the period covered. It is remarkable that so few of the links were hardened or even hardenable. Ease of manufacture clearly took precedence over serviceability."

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Circle 1700 on Page 48-B

THE ALLOYING ELEMENTS IN STEEL

Significant appraisal of the alloying elements in steel. Information engineers must have for best results. Basic reference for both research and application of steel making. *Edgar C. Bain – 312 pages – 6 x 9 – red cloth – illustrated – $5.00.* Clip and send to ASM Technical and Engineering Book Information Service, Metals Park, Novelty, Ohio.

who cares about the freezing process . . . *as long as it tastes good? Many production men, understandably enough, share the viewpoint of this small-fry. It doesn't matter how steel freezes in the ingot mold, just as long as the bar and strip and wire and other shapes perform well. Other than steelmakers, who should care about uniform material? You should care if you've ever run into trouble with stainless or high temperature alloys or tool steels. For higher reject rates, premature part failure, shortened tool and die life, increased production costs, and dissatisfied customers . . . all can be traced directly to the ingot. An ingot of weak structure or poor composition can mean trouble in every piece of steel that comes from it.*

That's why we say the exclusive MEL-TROL® process goes a step beyond quality control. It includes a new patented mold which controls the freezing process . . . forces impurities to the top of the ingot where they can be cut off and discarded. This MEL-TROL ingot is more uniform . . . freer from segregation. You get clean, sound, tough metal from surface to core in every lot of steel you order. Specify Carpenter MEL-TROL steels and avoid trouble in the future. Then you, too, can enjoy the luxury of saying: "I don't care how they make it as long as it performs so well!"

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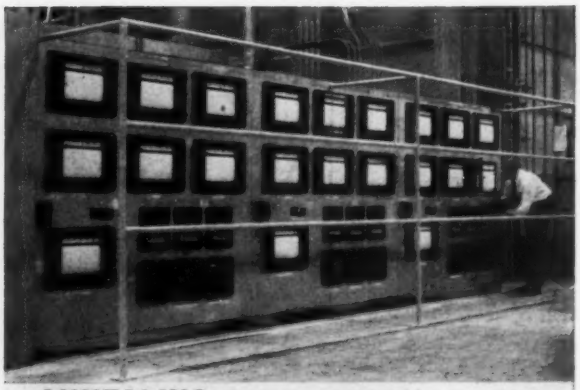
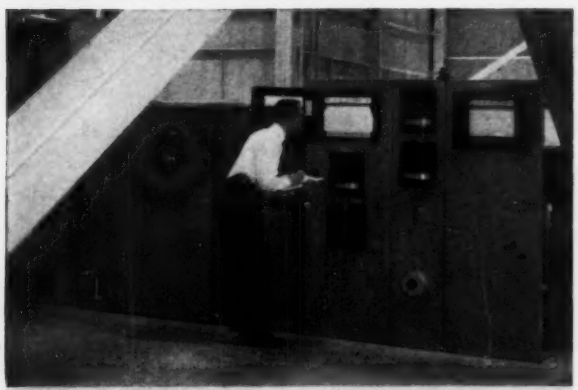
Webb Wire Division, New Brunswick, N. J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.

Circle 1701 on Page 48-B

SOAKING. These Bristol Dynamaster* instruments monitor soaking pit operation in new, multi-million-dollar aluminum fabricating plant of Anaconda Aluminum Company at Terre Haute, Indiana. Staff engineer analyzes record.



ANNEALING. Dynamaster* instruments here control and record annealing furnace temperatures in new Anaconda Aluminum plant. Over 11½ acres under one roof, the new plant produces aluminum sheets, extrusions, tubes and ingots.



HEAT TREATING. Anaconda staff engineer checks temperature records, produced by Bristol Dynamaster instruments, for vertical extrusion heat-treating tower, part of which is shown at left.

AGING. Dynamaster instrument panel at left controls and records temperatures in aging furnaces in new Anaconda Aluminum Company plant. Furnace operator at right is moving rack car into furnace.

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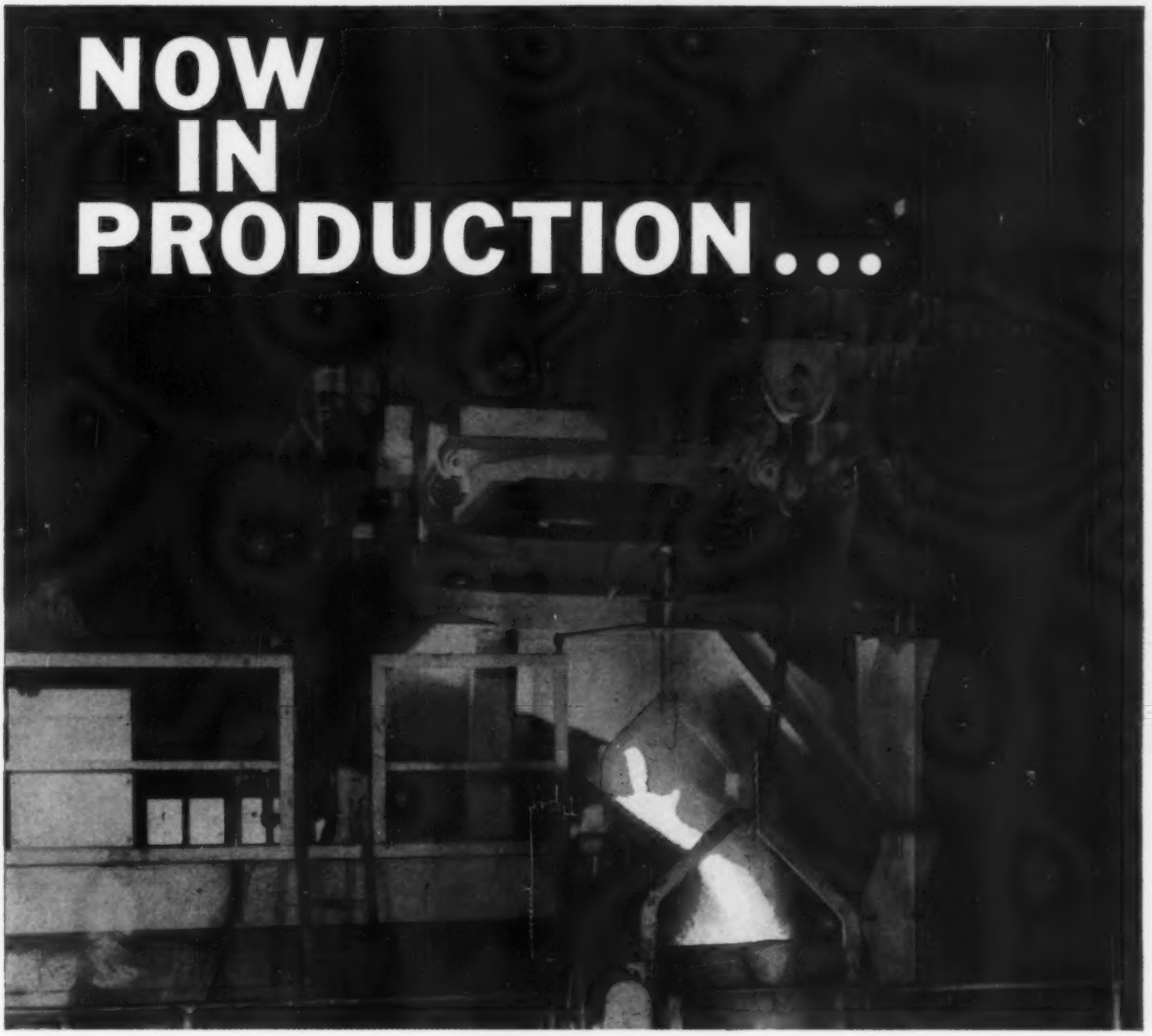
Circle 1702 on Page 48-B



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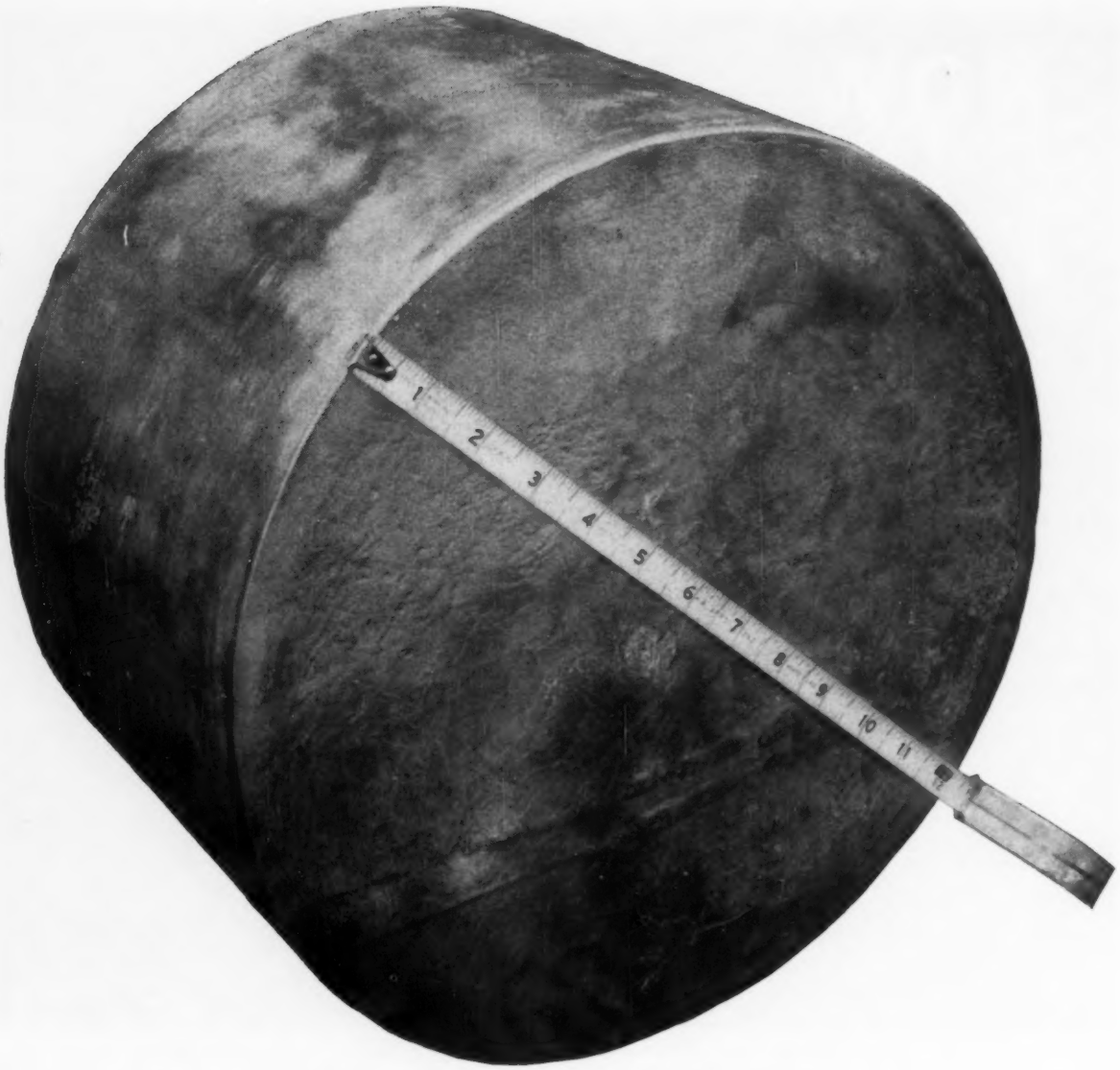
Circle 1703 on Page 48-B



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NOW...ONE FOOT DIAMETER MOLYBDENUM!

Now you can get General Electric molybdenum in diameters up to one foot! This is another first—from General Electric, of course—in PS (for pressed and sintered) moly.

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PS materials are versatile. They can be worked, melted or machined! Whether you forge, vacuum arc melt with consumable electrodes, or need to machine a product directly from a billet, tube or preform, there's a General Electric PS Moly product that can be engineered for you.

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Circle 1705 on Page 48-E

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Since 1955, Washington Steel has been the exclusive supplier of light gage stainless steel sheet for the outer covering of the Atlas missile. The reason is simple: Washington Steel pioneered in the art of rolling stainless steel to uniform gages and has been able to meet the exacting specifications set up by space engineers for this momentous undertaking.
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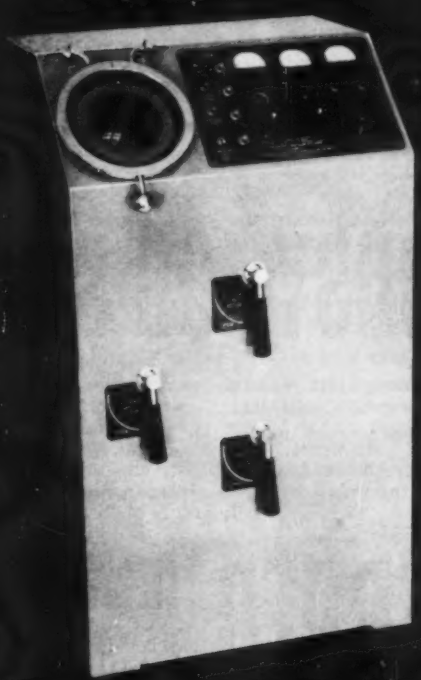

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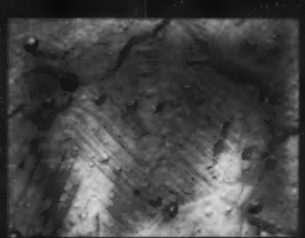

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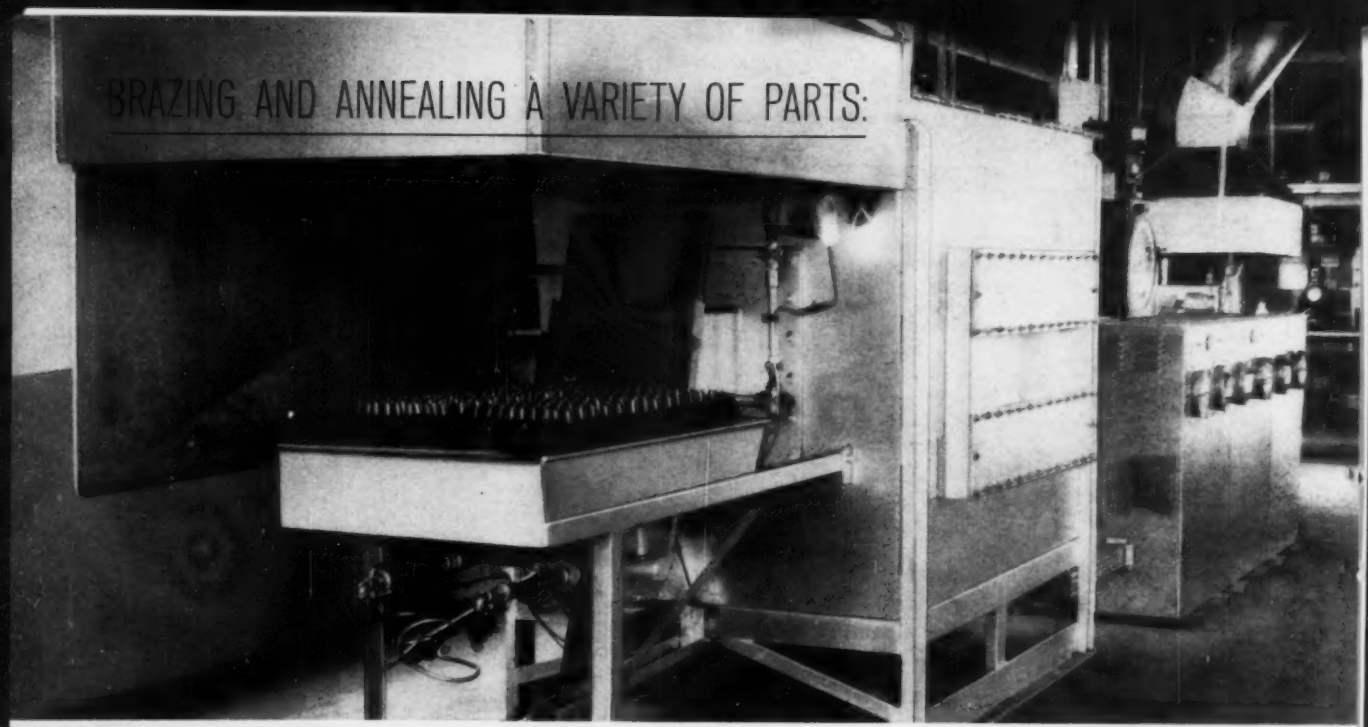
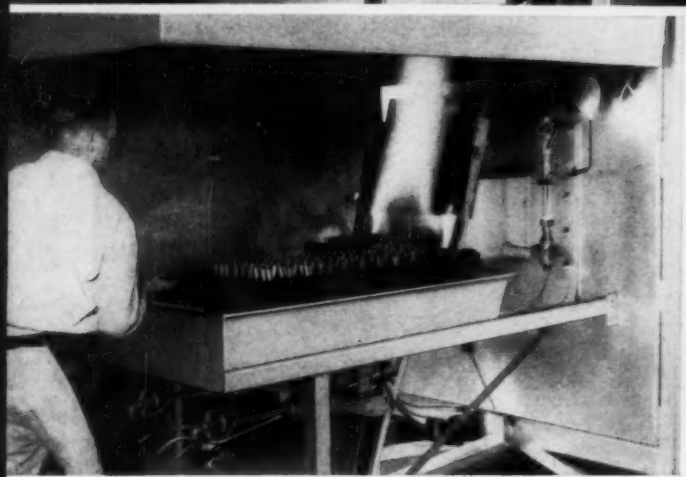
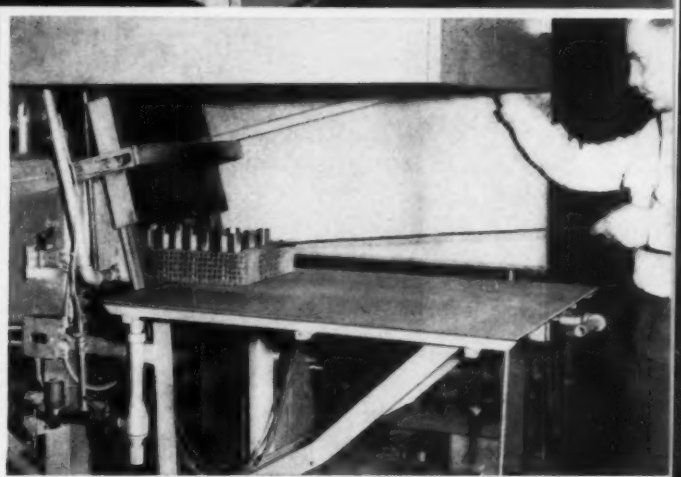
BRAZING AND ANNEALING A VARIETY OF PARTS:





Basket of parts is pushed from the end table through gas flame curtain of charging door into heating chamber. The charging door and inner refractory doors of heating chamber are pneumatically-operated.



Clean, bright brazed parts are drawn from the water-jacketed cooling chamber at the exit end of furnace. In this instance, four baskets can be cooled while one basket is being treated in the heating chamber.

COSTS MINIMIZED IN BUSY JOB SHOP

Processing metal parts for several manufacturers on a contract basis, Edward E. Russell Co., Wallingford, Conn. uses two Harper box furnaces for brazing with copper and silver alloys as well as for annealing. Parts from 1/4" in diameter up to 11" x 7" x 36" are treated at temperatures up to 2350°F. Each furnace handles up to 200 lbs./hr. net.

The first Harper furnace (shown above) went into operation in 1951 and the second during 1953. Both have been in continual use since installation with practically no lost time for maintenance.

The company reports that the furnaces have "not only proved extremely economical, but are exceptionally versatile, easy to control and productive of high quality work."

The next time you're considering the purchase of a furnace for brazing, sintering or annealing, you'll find it worth your while to discuss job requirements with a Harper representative . . . for Harper can build the furnace best suited to your needs: box, pusher, mesh belt hump or straight-thru, roller hearth, bell, elevator or pit. To obtain detailed information, write: Harper Electric Furnace Corporation, 40 River St., Buffalo 2, N. Y.

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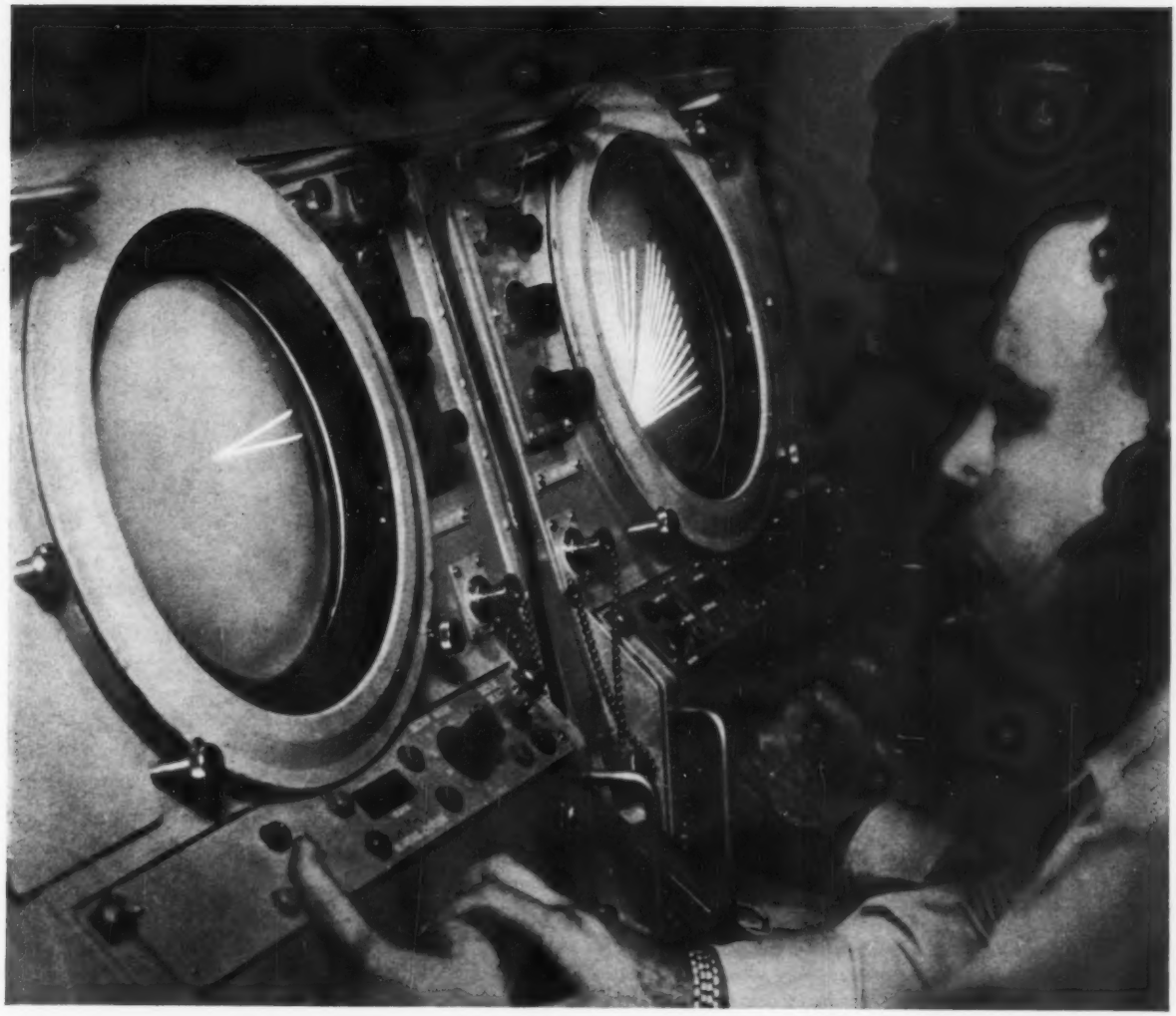
FOR BRAZING, SINTERING, BRIGHT ANNEALING, AND FORGING IN RESEARCH AND PRODUCTION

VISIT HARPER BOOTH 1875 AT THE METAL SHOW

Circle 1708 on Page 48-B



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Also exhibited will be detailed models of G.E.'s new and standardized lines of mesh belt, stainless strip bright annealing, gantry, elevator, and box furnaces; and nitrogen producers.

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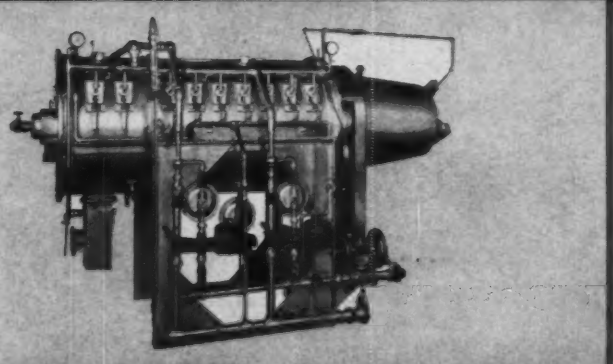
- LESS VALUABLE FLOOR SPACE NEEDED. Compact design uses minimum of floor space — far less than any conveyor type furnace.



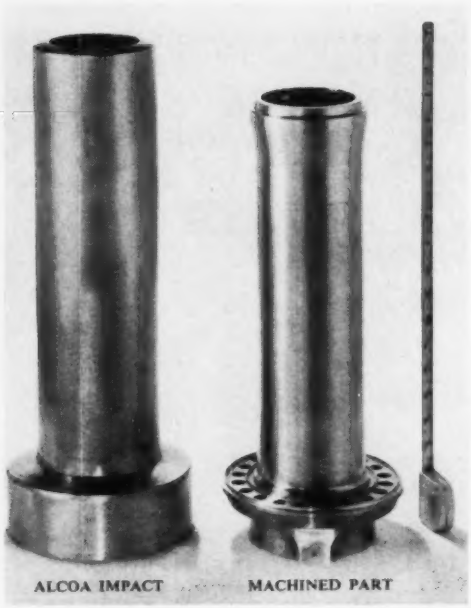
The "work in motion" principle of the peanut roaster scientifically refined and applied—produces the same COMPLETELY UNIFORM result to small parts heat treated in the illustrated AGF "Automotion" Rotary Retort Furnace Model No. 136MGE.

Over 82 Years of Quality Craftsmanship and Furnace Building Experience. Write Today for Complete Details on The New "Automotion" Series of AGF Rotary and Shaker Hearth Furnaces

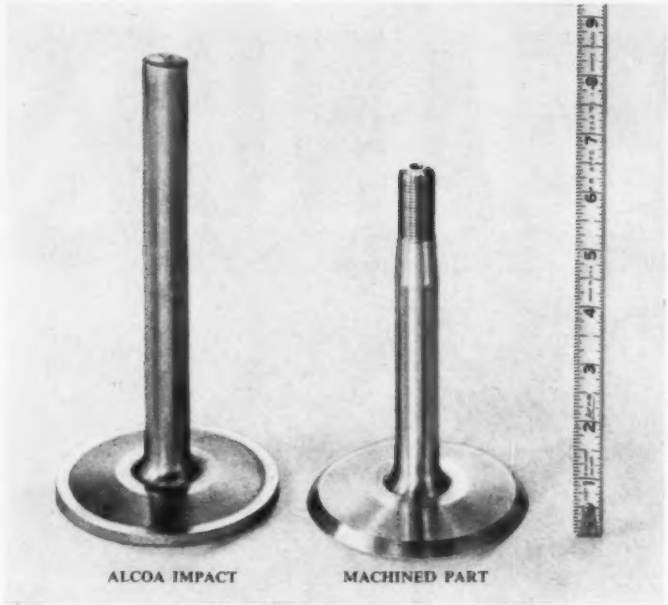
See Us at The Metals Show, October 17-21, Booth 1910B

AMERICAN GAS FURNACE CO.
1002 LAFAYETTE STREET — ELIZABETH 4, N. J.

Circle 1707 on Page 48-B

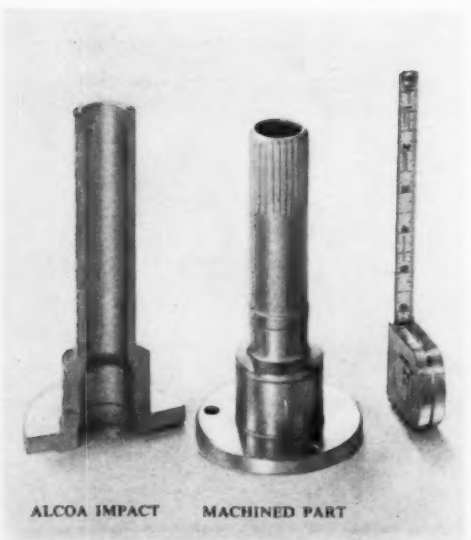


Use of an impact for this missile component provides significant savings in machining time and material cost.



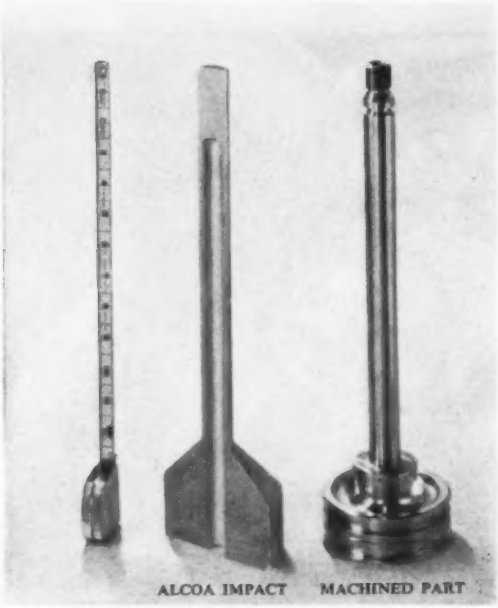
Impact eliminates prohibitive waste of stock previously encountered in machining this air compressor valve from rod stock.

IN IMPACTS... Alcoa

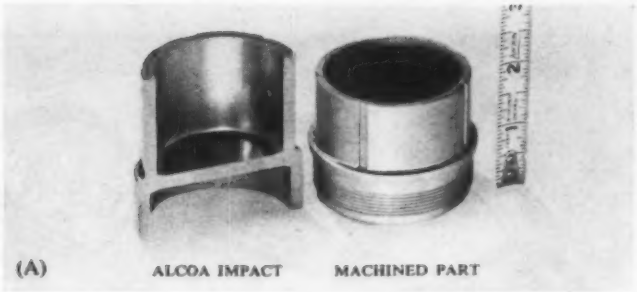


Impact replaces steel forging in which center hole had to be drilled. Cost of finished aluminum part is approximately half that of steel part.

Side-wall steps and grooves in the impact reduce hogging and milling operations in this missile component.



Impact's extremely precise center hole avoids costly deep drilling while impact's outside contour saves high machining chip loss.



(A) Impact incorporates close-tolerance indexing grooves and keys on both ends. Saves precision milling operations and reduces machining time and costs.

(B) Impact reduces machining waste and milling of flats—unavoidable if this sleeve cable connector were machined from heavy wall tubing.

puts the metal where you want it

Impact banishes deep drilling and wasteful machining required when machining this aircraft landing gear plunger from solid stock.

. . . to save time, money and metal in machining blanks

Every impact on this page is produced quick as a wink. Every one is produced in a strong, heat-treatable alloy with good machining characteristics. Every one incorporates a costsaving design feature—a flange, step, groove, keyway, stem, rib, cavity or deep hole. Every one is made to close tolerances—as close as ±0.005 in.—without draft. Every one eliminates excessive machining waste and costly operations such as hogging, milling, broaching or deep drilling. Every one is visible proof that in impacts, Alcoa puts the metal where you want it.

The more you know about impacts, the more uses—and savings—you'll find in your own production. See for yourself. Write for *Metal in Motion*, Alcoa's new 34-page brochure on impacts. Aluminum Company of America, 913-K Alcoa Building, Pittsburgh 19, Pa.

Alcoa puts the metal where you want it—
in castings, forgings, extrusions, screw machine parts and impacts.

ALCOA ALUMINUM

For exciting drama watch ALCOA PRESENTS
every Tuesday evening—ABC-TV

Visit the Alcoa Booth (No. 1410) at the National Metals Exposition in Philadelphia, October 17-21

Circle 1712 on Page 48-B

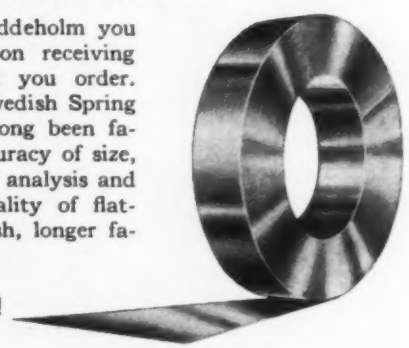
At Your Fingertip . . . UDDEHOLM Spring Steels

STOCK DELIVERY—WIDEST SELECTION—ULTIMATE QUALITY

There are large stocks of almost every grade, analysis and size in every Uddeholm Steel Service Center . . . New York, Cleveland and Los Angeles. You can obtain rapid delivery of tempered, annealed, polished, blue, scaleless or stainless spring steels in widths, thicknesses, lengths and edges to fit your needs exactly. Thicknesses range from .001" to .125", widths from $\frac{1}{8}$" to $16\frac{1}{4}$" with square or rounded edges.

Uddeholm Specialty Steel Service Centers offer a wide range of analyses—straight carbon steels such as SAE 1075 and SAE 1095—Alloy Spring Steels with nickel, chromium, etc., and Stainless Spring Steels for special applications.

And, with Uddeholm you can depend on receiving exactly what you order. Uddeholm Swedish Spring Steels have long been famous for accuracy of size, uniformity of analysis and hardness, quality of flatness and finish, longer fatigue life.



For more information, write for your free 50 page catalog-stocklist TODAY!

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TOOL AND DIE STEELS
COLD ROLLED SPRING STEELS

UDDEHOLM COMPANY OF AMERICA, INC.

155 East 44th Street, New York 17, N. Y. • MUrray Hill 7-4575

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TOOL STEEL WAREHOUSE DISTRIBUTORS: Rockford, Ill.: Rockford Industrial Steel Service, 2229 Twenty-Third Ave. WOodland 3-5463

Circle 1713 on Page 48-B

"There's always room for more!" Sure, the VCA Exhibit (Booth #204) at the Metal Show in Philadelphia on October 17 to 21 will be a popular gathering place. That's one reason why you'll want to pay us a visit.

There are other good reasons for being there, too. VCA is *always* headquarters for the latest information on ferroalloy developments and applications. It is the place to go for the most complete line of quality ferroalloys . . . for experienced advice and counsel on alloying problems . . . for prompt service and highly efficient technical cooperation. As a leader in the field, with its modern research and production facilities, VCA is in fact your best source of progress and improvement in steel through ferroalloys.

We're looking forward to seeing you. Vanadium Corporation of America, 420 Lexington Avenue, New York 17, N. Y. • Chicago • Cleveland • Detroit • Pittsburgh

VANADIUM
CORPORATION OF AMERICA
Producers of alloys, metals and chemicals

Circle 1717 on Page 48-B

the new Leitz **MICRO-METALLOGRAPH**

engineered specifically for modern industry

Availability of a Le Chatelier type LEITZ MICRO-METALLOGRAPH has been eagerly awaited by industrial scientific laboratories. With this new instrument, precise details of metallurgical specimens may be viewed simultaneously on the 30" projection screen as well as through the binocular observation tube. The newly-developed, powerful XENON lamp provides ample illumination to permit observation in a normally lighted room. Photomicrography of specimens is quickly and easily accomplished with pre-aligned 5" x 7" camera or, if desired, a Polaroid-Land 4" x 5" camera back. Engineered specifically to meet the needs of the modern, metal working industry the new LEITZ MICRO-METALLOGRAPH "sets a new standard for metallurgical observations."

- Inverted microscope stand with mechanical stage, coarse and fine focusing
- Xenon lamp with 7 filters in push-button, quick-change mounts
- Eye pieces with 30% wider field, in binocular tube
- New, "Plano," flat-field objectives from 3.2 to 160x
- Projection and viewing screen in cast housing, 30" diameter
- Special 5"x7" camera with adaptor for attaching Polaroid-Land 4"x5" camera back

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FIRST IN PRECISION OPTICS

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Please send me additional information on the new MICRO-METALLOGRAPH, Model MM.

Name _____

Street _____

City _____ Zone _____ State _____

Circle 1718 on Page 48-B

THE FOOTSTEPS OF GENERAL ALLOYS MARK THE PATH OF AN INDUSTRY

1 . . 5 . . 10 . . 15 . . 20 . . 25 . . 30 . . 35 . . 40 . . 42

YES, 42 CONSECUTIVE YEARS, AS USUAL, AS A MAIN EXHIBITOR OF HEAT RESISTING AND STAINLESS CASTINGS AND FABRICATIONS AT THE

NATIONAL METAL EXPOSITION

THERE IS NO SUBSTITUTE FOR EXPERIENCE

General Alloys Company is an engineering organization with 42 years experience in the design and manufacture of heat resistant and stainless steel castings and fabrications. The design of high temperature tooling is our specialty. Consult our specially trained sales engineers in Booth 930 at the National Metal Show concerning your alloy problems.

GENERAL ALLOYS COMPANY

401 West First St., Boston, Massachusetts

the only producer of both heat resisting castings and fabrications

Circle 1719 on Page 48-B

Q-ALLOYS THE QUALITY NAMES IN ALLOY FOR HEAT CORROSION ABRASION **X-ite**

"Very pleased with all the advantages offered by Tri-Lok. Always prefer shipments to be made in this form due to handling ease, safety and convenience."
NEW YORK SMELTER

"ALCAN TRI-LOK ingots arrive compact and stay compact until we use them. They stack safely, stably—even three or four bundles high. And when straps are cut, they stay in place until fork-lift pickup."
CALIFORNIA EXTRUDER

"We're very enthusiastic about new ALCAN TRI-LOK ingots. Always liked Alcan ingot anyway . . . even more so with Tri-Lok. Mainly from point of view of stacking and handling."
EASTERN EXTRUDER

"TRI-LOK ingots cut our unloading time quite a bit. They don't shift in bundles . . . but stay in place for easy storing and fork-lift handling."
MIDWEST ALUMINUM PRODUCTS MANUFACTURER

Despite the stability of TRI-LOK bundles, there's never a separation problem—*just lift to separate!*

Here are some typical examples of what users are saying about Aluminium's newest ingot development—ALCAN TRI-LOK ingot.

Designed for more efficient handling, the new ingots lock one to another, not in just one, but in three different ways. The resultant stability means greater speed, simplicity and safety wherever ingots are handled.

In car unloading, you find bundles arrive in excellent condition ready for quick pickup by fork lift truck. In-plant moves, too, are greatly simplified because no pallets or special slings are needed. Even after strap removal, TRI-LOK bundles remain securely intact on trucks, floors or inclined ramps.

See for yourself how TRI-LOK ingots improve worker safety . . . save time in carrying, storing and remelt charging. Just telephone or write us today.

Aluminium Limited

ALCAN

Ingot Specialist...serving American Aluminum Fabricators—

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Circle 1720 on Page 48-B

Furnace value comes in a variety of boxes at North American

North American Aviation, Inc., Los Angeles, had three separate heat treating operations. Each called for special equipment. Hevi-Duty met each with a box furnace that was quickly adapted for the specific job.

This illustrates two important points. 1. You need never alter a good system to fit the equipment. Hevi-Duty engineers are qualified to recommend entire heat processing systems and to design the equipment to fit each one. 2. In most cases this can be done with a minimum of engineering time. For Hevi-Duty builds the most complete line of fuel-fired and electric furnaces and ovens in the industry. If an adaptation is necessary, it usually is a minor adaptation from a proven unit.

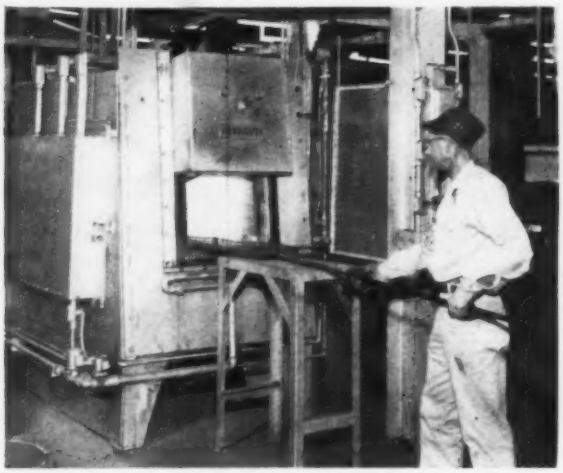
Why not ask a Hevi-Duty sales engineer for his recommendation? He will be glad to come in without obligation.

HEVI-DUTY

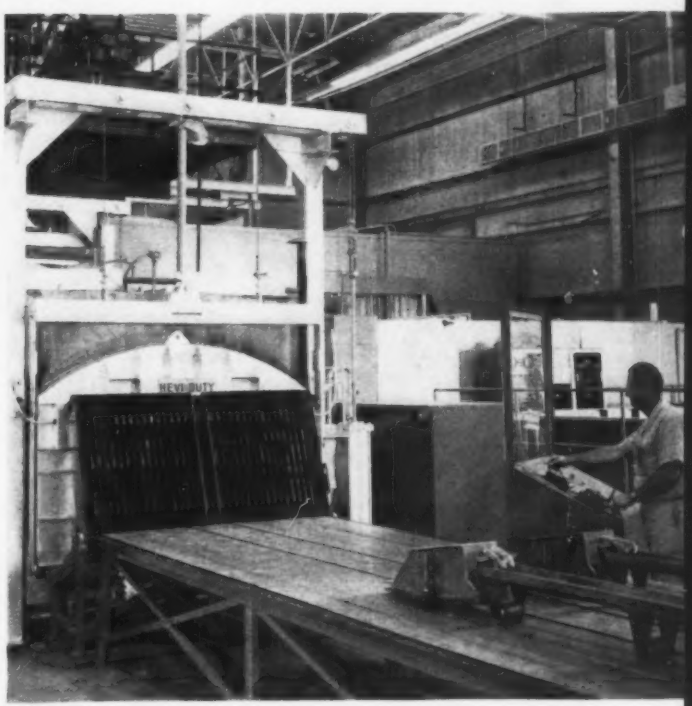
Electric and Fuel-Fired Industrial Furnaces and Ovens

B P C — A Division of Basic Products Corporation

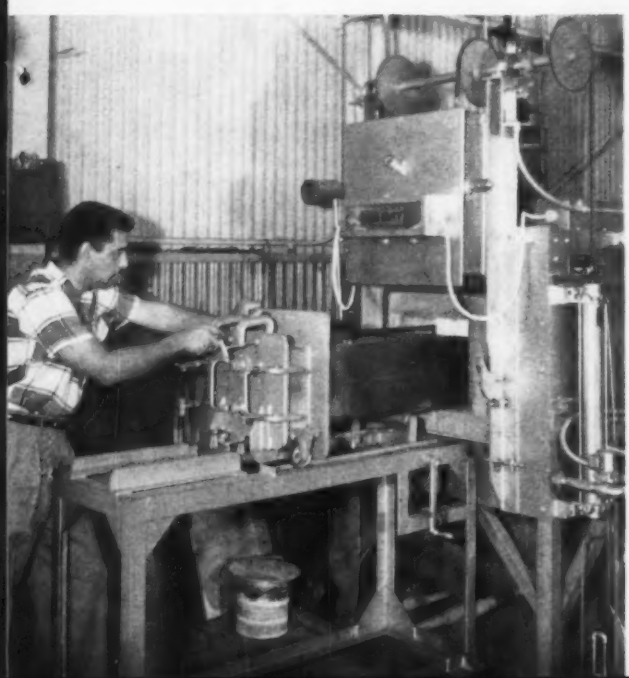
Hevi-Duty Electric Company, Milwaukee 1, Wis.



This box furnace was designed to handle copper brazing and heat treating in an endothermic atmosphere. Its water-jacketed cooling chamber and oil quench tank are atmosphere-protected. There are door curtain burners at each end. North American reports it is getting exceptionally clean work from this furnace due to the enclosed quench. ***For complete information ask for Bulletin No. 153.***



This 280-kw box furnace is used for brazing stainless steel honeycomb sheets. It has been equipped with automatic feed and discharge, air-operated doors, and three separate zones of control. Even without a fan, this furnace has been certified at ±10°F. at 1600°F. ***Request Bulletin 441A.***



It takes real versatility to handle the jobs this furnace is required to do. Used for experimental work in the heat treating laboratory at North American, the furnace operates in a range from 250°F. to 2200°F. with all types of atmospheres. Temperature uniformity is reported at ±10°F. over the entire range. A removable fan enables convection or non-convection heating. The furnace can be used with an air-operated door or with a retort and plug-type door on a movable stand. ***Ask for Bulletin 1046A.***

Circle 1721 on Page 48-B

AT THIS LARGE STEEL PLANT...

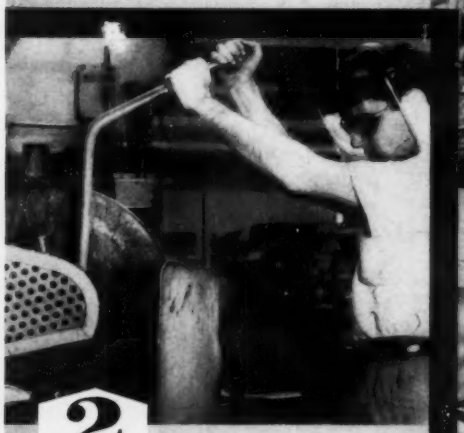
There's no room for guess work when making a heat!

When working an open hearth or electric furnace heat, melters at a major steel corporation are told the exact analysis of the bath in less than ten minutes by the spectroscopic laboratory. To see how these amazingly fast results are obtained, let's follow a sample from the melt floor to the spectroscopic laboratory for an analysis.

1

SAMPLE — 1 MINUTE

At the time a spoon of molten metal is taken, the spectroscopic laboratory is notified sample is on the way. Metal is poured in a specially designed quick-chill mold and is sent to the chemical laboratory.



2

CUT AND IDENTIFIED

1 MINUTE

Sample is cut quickly on an abrasive cut-off wheel and is labeled with an identification tape. Previously samples were etched for identification—now tapes are prepared in advance to speed the overall operation.

3

DELIVERED TO "SPEC" LAB

40 SECONDS

The sample comes to the spectroscopic laboratory through a pneumatic tube 1,980 feet long. It arrives in 40 seconds from the chemical laboratory.

4

POLISHED

30 SECONDS

Sample is polished on a horizontal disc grinder utilizing a stainless steel platen. The design of this polisher assures a perfectly flat surface on every sample.

ANALYZED AND REPORTED

5

4 MINUTES

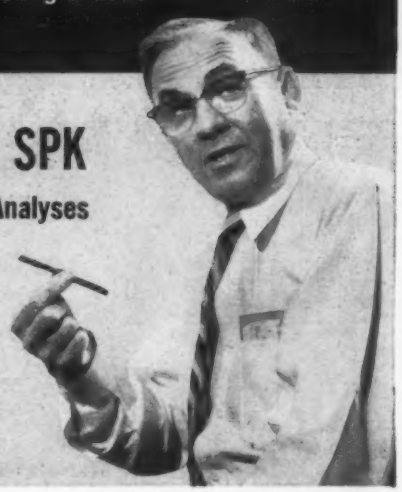
The sample is run in duplicate on a direct reader. The analysis which is automatically recorded is reported by "teletalk" to the melter or first helper on the furnace floor.

RESULTS obtained quickly and economically from the spectroscopic laboratory — permit this firm to make steels to very exacting specifications, thereby insuring a better and more uniform end product.

"NATIONAL" GRAPHITE RODS GRADE SPK

Help Contribute to the Confidence Limits of Spectrographic Analyses

Grade SPK graphite rods, a newly introduced product, are more uniform within the rod, from rod to rod and from box to box. This feature is reflected in improved reproducibility, precision and accuracy, especially where high-alloy constituents are involved.



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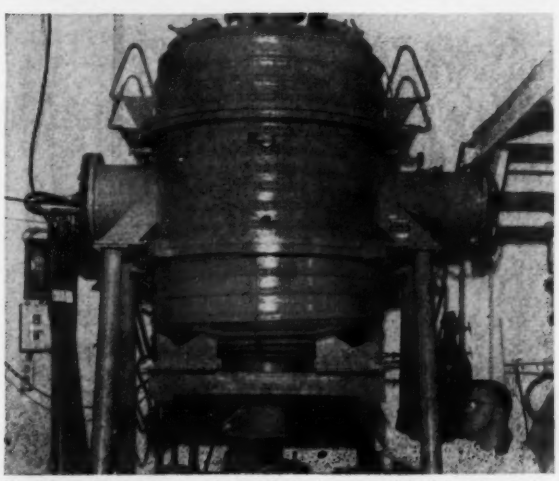
NATIONAL CARBON COMPANY

Division of Union Carbide Corporation • 270 Park Avenue, New York 17, New York

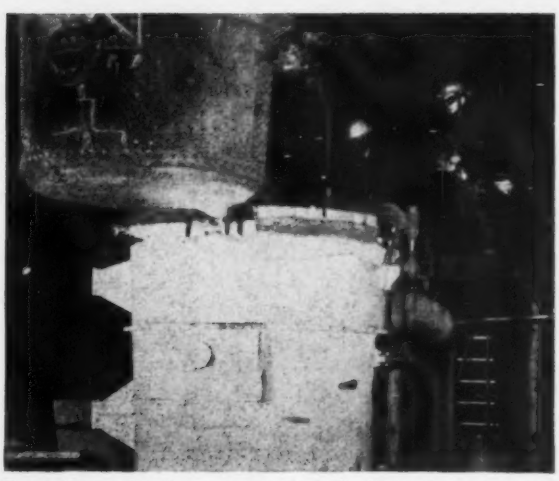
IN CANADA: Union Carbide Canada Limited, Toronto

UNION CARBIDE

One of the largest cold-wall vacuum heat treating furnaces ever built, capable of operations at 2250 F. was supplied by Stokes to Convair (Astronautics) Division of General Dynamics Corporation. The huge furnace will be used in brazing and heat treating the high alloy steels used in the production of the Atlas ICBM. It has a vacuum chamber 12 feet long and 9 feet in diameter.



Uranium melting on a production basis is accomplished by this Stokes induction melting furnace at Atomics International. Designed for safety and convenience, the furnace is serviced from the top and features a removable bottom section to facilitate handling of cast materials.



First acid open hearth, vacuum stream ladle degassed, air-pouring of multiple ingots in the U. S. took place at Ohio Steel Foundry in Stokes equipment. Results showed low hydrogen values, good inclusion reduction and excellent physical property improvement.

CUSTOM APPROACH TO YOUR UNACCUSTOMED PROBLEMS...

a Stokes specialty in vacuum metallurgy

Staffed and equipped to undertake projects which contain unusual problems, Stokes offers the most comprehensive background of vacuum metallurgical experience and know-how available today. Stokes is geared to tackle even the most complex assignments . . . assignments for which the application of high vacuum is the only practical solution.

New vacuum methods and techniques—first introduced by Stokes—are helping to capitalize on more and more opportunities in the metallurgical field. These advances are helping industry break through old bottlenecks . . . while reducing operating costs. In the nuclear field, for example, Stokes equipment has been used to develop new methods for plutonium melting and casting, uranium melting on a production basis, and radioactive materials handling. In metal refining, hydrogen embrittlement is being reduced with the aid of Stokes vacuum stream degassing equipment. In melting, heat treating, sintering and brazing . . . and in vacuum metallizing of thin and heavy coatings for decorative and functional applications . . . Stokes leads the field in new developments.

Advantages that take the guesswork out of operations . . . and brighten profit potential are inherent in Stokes equipment. For instance, we have demonstrated our capability in supplying a complete turnkey installation—erected, tested and delivered in operation. And our stocked components mean faster delivery, fewer costly holdups. All Stokes systems are offered complete . . . Stokes is your single source of responsibility for performance and reliability both before and after the sale.

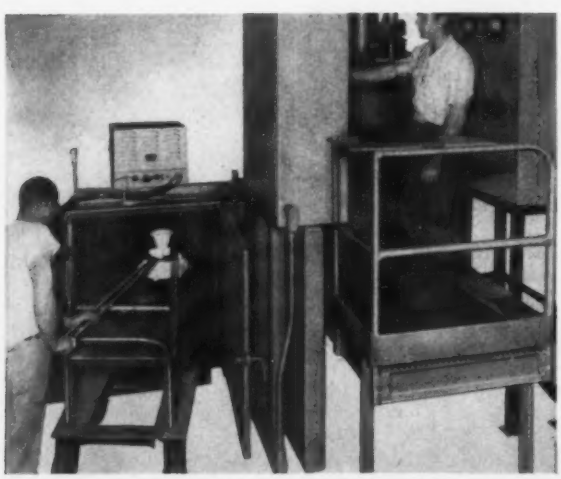
Let Stokes put its unique experience and facilities to work on your problems. Our Engineering Advisory Service will help you in planning and designing an installation that will best serve your exact requirements. And whatever those needs are, the inherent flexibility of Stokes design concepts is assurance that they will be satisfied.

STOKES

Vacuum Metallurgical Division

See us at the Metal Show—Booth 1625 Convention Hall, Philadelphia, Pa.

F. J. STOKES CORPORATION • 5500 TABOR ROAD, PHILADELPHIA 20, PA.



At Misco Precision Casting Co., semi-continuous vacuum melting and casting are being accomplished in two Stokes induction furnaces. Successive charges of the metal are introduced into the vacuum chamber from the outside, loaded into the crucible, melted, poured, and the cast pieces (in their molds) removed from the chamber . . . without breaking the vacuum.

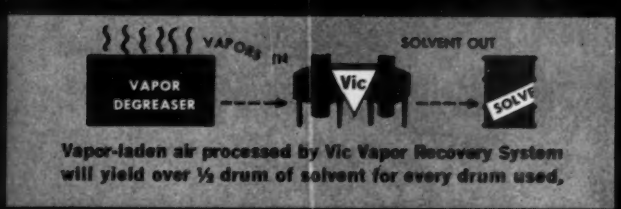
Vacuum equipment capable of brazing panels in excess of 50 sq. ft. is being used in pilot operation by Grumman Aircraft Engineering Corporation to fabricate structures for the "Eagle" air-to-air missile. The Stokes equipment employs a new procedure which eliminates expensive and time-consuming welded "envelopes" to enclose the work. And high vacuum eliminates the need for costly inert gas.

BOOTH 1717

SEE THE **VIC** VAPOR RECOVERY
SYSTEM AT THE
NATIONAL METALS EXPOSITION

VAPOR DEGREASING SOLVENT COSTS CUT 50%...IMPROVES WORKING CONDITIONS

Now! For the first time—a practical, compact, easy to install Solvent Vapor Recovery System*! Solvent vapors normally exhausted outside or lost to the atmosphere in working areas now recovered and returned as solvent! Vic patented Vapor Recovery Systems* are moderately priced—pay for themselves in an extremely short time!



Vapor-laden air processed by Vic Vapor Recovery System will yield over ½ drum of solvent for every drum used.

*Protected by one or more of the following patents: Pat. No. 2,480,320; 2,772,747; 2,760,594; 2,910,137. Canadian Pat. No. 470,085 and other Patents applied for in U.S. and Foreign Countries.

Currently in use by such firms as:

MINNEAPOLIS HONEYWELL
SUPERIOR PLATING, INC.
BROWN AND BIGELOW
GREAT NORTHERN RAILWAY
GENERAL ELECTRIC COMPANY

VIC

If you care—you'll compare and buy

MANUFACTURING COMPANY
1313 Hawthorne Ave. • Minneapolis 3, Minn.

Atmosphere generator tube to resist temperatures of 1800°-2300°F is installed by Lindberg Engineering Company, Chicago. Tube is centrifugally cast from Duraloy "HOM"*, a special high-nickel alloy developed by The Duraloy Company for hot strength in oxidizing atmospheres.

Simple way to "treat" heat-treating equipment to longer tube life at 1200°—2300°F

Specify heat resistant nickel alloy castings for tubes . . . or trays, belt links, fittings . . . for a bonus in extra service

For furnace or generator parts threatened by thermal fatigue, consider the proved heat-resistance of nickel-chromium-iron alloy castings. Available in a variety of types, these alloys offer a wide range of properties for useful strength and long life—in the most demanding environments.

Outstanding performance records. At temperatures above 1200°F, the high-nickel alloys set high standards for resistance to thermal shock, to reducing or oxidizing conditions, to scaling or embrittlement. Suitable high-nickel alloy castings provide the right combinations of properties for tubes or trays; for racks or retorts; for a wide variety of furnace hardware.

How to find the alloy that solves the problem. To help you select the best possible material, we offer a new and data-packed 64-page booklet, "Heat Resistant Castings, Corrosion Resistant Castings . . . Their Engineering Properties and Applications." You'll find it useful when considering such design factors as sizes, shapes, atmospheres, load or cycling requirements, fabricating or assembly methods. Write today for this helpful booklet.

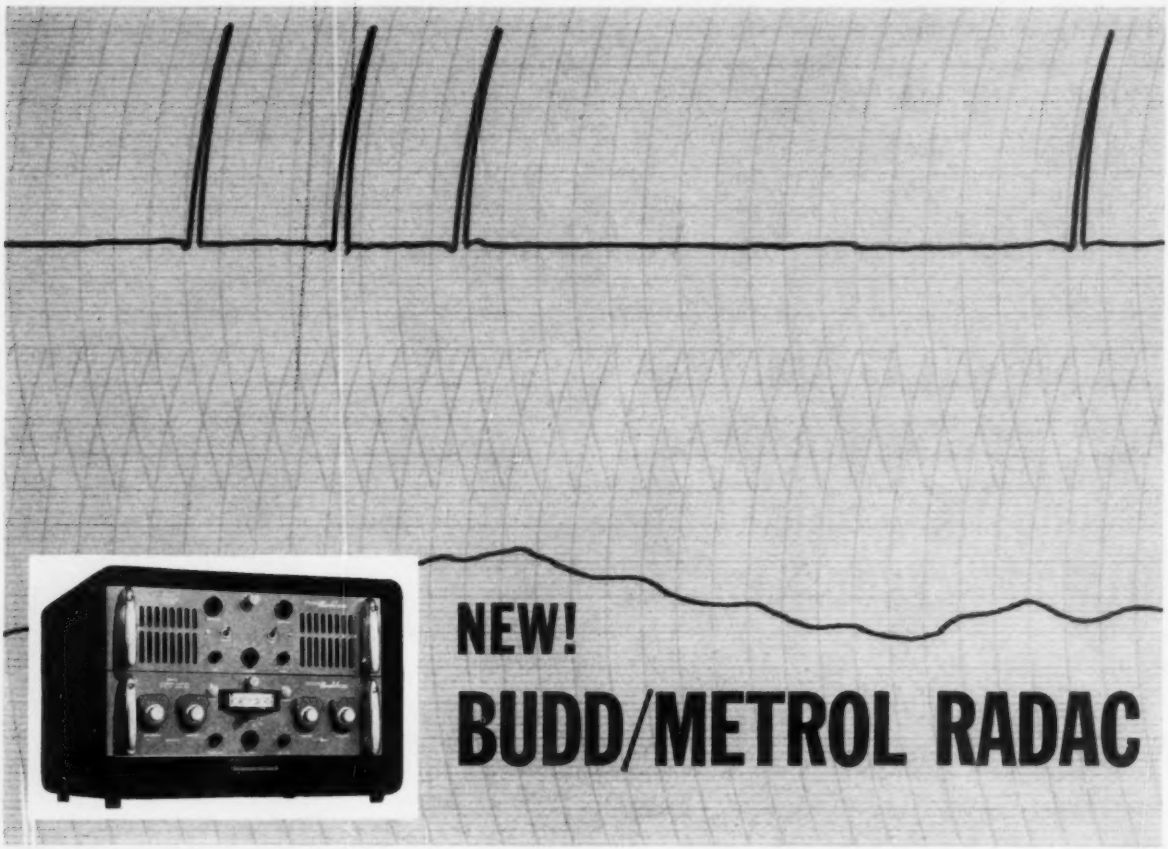
*Registered trademark, The Duraloy Company

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

Circle 1725 on Page 48-B



NEW!
BUDD/METROL RADAC

. . . multiple-frequency eddy current inspection unit

The Budd/Metrol RADAC Model 302 . . . latest addition to Budd's expanding line of specialized equipment for quality control . . . is a two-channel electromagnetic instrument that brings new versatility, sensitivity, selectivity and speed to the nondestructive testing of metals and metal products. Combining the principles of Fourier analysis and phase analysis for the first time, the RADAC's flaw detection channel ignores internal stresses, dimensional variations and variations in physical properties . . . is sensitive almost exclusively to discontinuities. Its second, or absolute channel, complementing the first channel, is selectively sensitive to such variables as diameter, wall thickness, eccentricity, coating and plating thickness and physical properties.

Simultaneous two-channel operation is obtained from a single sensing head, and both outputs can be recorded at the same time with a dual channel oscillograph recorder. Focused field test coil sensing heads . . . another exclusive RADAC feature . . . increase the information content of the test signal by properly shaping the electromagnetic field, providing exceptional sensitivity and ability to resolve variables.

The wide choice of test frequencies available with the RADAC covers the range from 1 kilocycle to 4 megacycles. Test coils include OD, ID, area probe and microprobe types. Frequency change boards and test coils are supplied as plug-in units for fast changing, making the RADAC a highly flexible tool for both surface and deep inspection of flat stock, bar stock, tubing and varied other shapes. Punched card programming is available on single-channel RADAC Model 440, enabling RADAC inspection to be applied under production line conditions by semi-skilled personnel. **For detailed description, write for Bulletin IM-1000.**

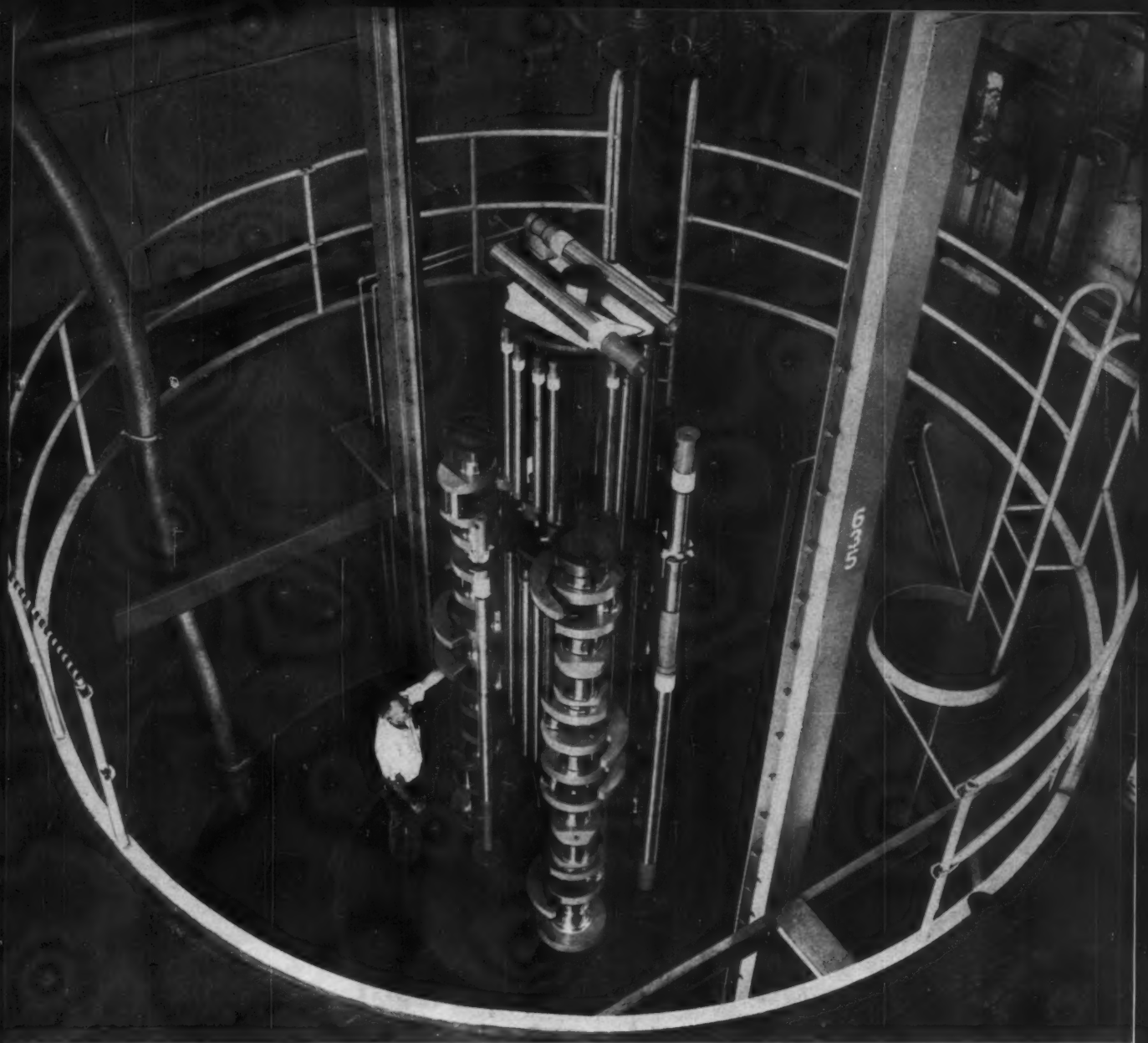
Other outstanding test equipment from Budd/Metrol: Model 810 Electromagnetic THICKNESS GAGE . . . Model 910 HEATCHECK for alloy identification . . . both fully transistorized and portable. Ask for Bulletins IM-1001 and 1002.

INSTRUMENTS Budd DIVISION

THE BUDD COMPANY • P.O. Box 245 • Phoenixville, Pa.

Consult your phone book for sales offices in: Atlanta, Ga.; Oak Park, Ill.; Detroit, Mich.; Seattle, Wash.; Dallas, Tex.; Los Angeles, Calif.
In Canada: Budd Instruments, Ltd., 170 Donway West, Don Mills, Ont.

Circle 1731 on Page 48-B



WHO FORGES THE TOUGH ONES?...
and nitride-hardens them, too?

National Forge does it—with a nitriding installation that is one of the largest and most modern in existence. Now diesel crankshafts, pump eccentrics, compressor pistons and rods, gears, marine couplings, and many other machinery parts are not only *forged* at National, but *nitride-hardened* to add strength and reduce wear. Vertical nitriding furnaces like the one illustrated will accommodate forgings up to 16 feet in length.

National Forge also has its own basic electric melting facilities and produces all the usual types of nitriding steels, including the recently developed 5% nickel, 2% aluminum grade. For further information, write for bulletin NH-1058.

NATIONAL FORGE COMPANY

IRVINE, WARREN COUNTY, PENNSYLVANIA

NF 60-01

For more information on "the tough ones," and the machinery that makes them "best"—write for bulletin NFO

Circle 1727 on Page 48-B

Typical Hauserman interior wall installation.

The E. F. HAUSERMAN COMPANY

Gets Dead Flat Sheet Steel with VOSS Roller Levelers

...and saves time and money doing it!

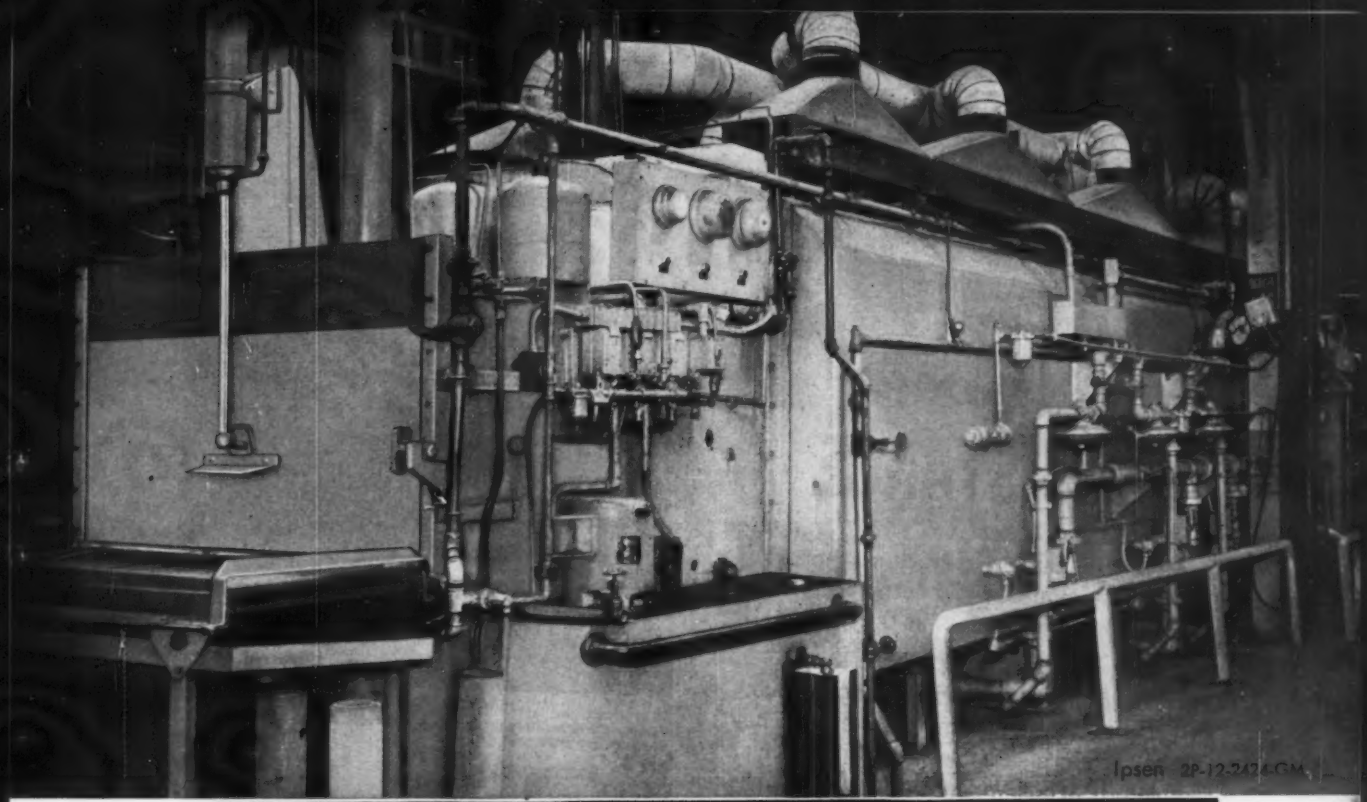
Hauserman standards are *tough*. Every sheet of steel used in a Hauserman movable interior wall is inspected on a slate table for absolute flatness. Before Voss levelers were installed, the company used stretcher-leveled sheets ... and still had to reject 33% as not meeting their severe specifications. Now steel is ordered in coils, and Voss-leveled on their own processing line. Rejects are consistently held under 5%, and the company gains the economy and flexibility of handling steel in coil form. Voss levelers have operated at Hauserman for 10 trouble-free years. They help the company maintain the most rigid quality standards in the movable partition industry.

Voss levelers are currently at work in plants of many primary steel and aluminum producers and major fabricators. Applications include high speed galvanizing lines, hot and cold rolled shear lines, steel plate, aluminum sheets and coils, and others. Let Voss put its experience to work on your leveling problems.

Voss ENGINEERING CO.

7301 Penn Ave. Pittsburgh 8, Pa. Churchill 2-4422

Circle 1728 on Page 48-B



Production Carburizing

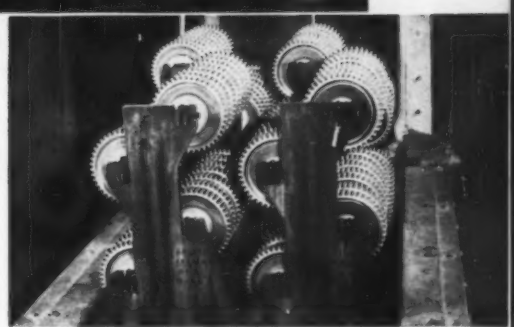
Five years ago the first Ipsen Double Row 4-Zone Pusher was built. It is now six years since the first Deep Case Carburizing Unit was built. BIG Ipsen controlled atmosphere pushers have given unexcelled metallurgical results!

Check these features when you consider a carburizing furnace. They are exclusive with Ipsen.

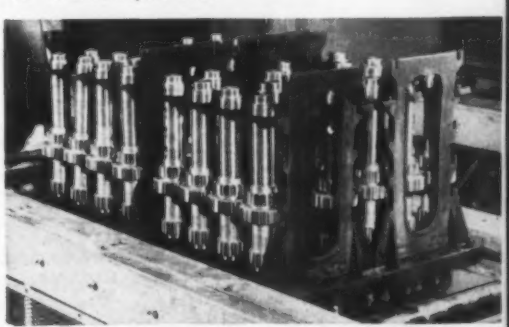
- Enclosed Charging Mechanism (Pat. No. 2,896,775)
- Chain Discharging Mechanism (Pat. No. 2,842,349)
- Baffles for 100% Forced Convection Heating (Pat. No. 2,788,205)
- Ceramic Heating Tube Mounting (Pat. No. 2,822,798)
- Ceramic "Flame-Busters" (Pat. No. 2,861,596)
- Ceramic Fan (Pat. No. 2,730,352)
- Water-Cooled Fan Motor (Pat. No. 2,800,317)
- Quench Oil Flow System (Pat. No. 2,854,013)

Other Patents Pending

Ipsen Pusher furnaces are described in Bulletin P-59. Send for your copy today.



This charge of steel gears is typical of work handled in Ipsen Production Carburizing Furnaces. Heating was 1700° F for 10 hours. Quenching was in oil at 150° F. Case depth: .045".



Countershafts ready for charging into Ipsen Production Carburizing Furnace. Heating time was 10 hours at 1700° F; quenching was in oil at 150° F. Case depth: .045".

AUTOMATIC Ipsen HEAT TREATING UNITS

IPSEN INDUSTRIES, INC. • DEPT. 23 • P.O. BOX 500 • ROCKFORD, ILLINOIS

Circle 1729 on Page 48-8

CARBORUNDUM'S TECHNICAL INFORMATION ON UNUSUAL REFRACTORIES **Data sheet**

Choosing materials for

CORROSION RESISTANCE

Though seldom associated with resistance to corrosion, certain refractories made by Carborundum outlast and outperform other materials of construction—as the table below indicates.

These special refractories withstand many gases, acids, salts and molten metals. They can be used as small, specialized parts or as complete hearths, walls, and roofs of large furnaces and other processing equipment, (see pictures at right).

In addition to essential corrosion resistance, these unique refractories withstand temperatures of from 2800°F to over 3000°F, carry heavy imposed loads, and are virtually unaffected by abrasion.

The tables below offer a very rough guide to properties and applications. Feel free to call on Carborundum for more comprehensive data that can be used in solving your particular problem.

Arch, jambs and sidewalls of CARBOFRAX® silicon carbide in this aluminum reverberatory furnace have resisted attack by corrosive molten aluminum for more than two years.

These parts of REFRAX® nitride-bonded silicon carbide, a Carborundum refractory, have exceptional resistance to corrosion. They are made in complex and accurately dimensioned shapes. Adapted to many installations, REFRAX shapes frequently outlast expensive alloys.

TYPICAL APPLICATIONS INVOLVING SEVERE CORROSION

- Generators handling superheated steam, oxygen and pulverized coal
- Aluminum reduction cells
- Rock wool furnaces
- Wire guides and blocks in pickling tanks
- Mannheim furnaces
- Hydrogen chloride burners
- Multiple hearth roasters, also rabble blades and teeth
- Artificial gas generators
- Spray nozzles
- Aluminum furnaces and pumps for molten aluminum
- Sinker rolls for aluminizing
- Acid slurry pumps
- Incinerators
- Slag bottomed boilers

CHEMICAL RESISTANCE OF TYPICAL CARBORUNDUM REFRACTORIES

G = Good F = Fair NR = Not recommended

	Silicon carbide	Aluminum oxide
MOLTEN METALS		
AL	G	G
Sb	F	G
Cu	G	G
Fe	NR	G
Mg	F	G
Ni	NR	G
ACIDS (Heated)		
HHO_3	G	G
H_2SO_4	G	G
ACIDS (Heated)—Contd.		
H_3PO_4	F	G
HCl	G	G
GASES		
CO_2	G	G
H_2O	G	G
O_2	G	G
H_2	G	G
Cl_2	NR	F
SO_2	G	G
S_2	F	G

Write today for your free copy of "Super Refractories by Carborundum." The address: Dept. M-100, Refractories Division, Perth Amboy, N. J.

For engineered refractories, count on **CARBORUNDUM®**

Circle 1730 on Page 48-B

MAN, METALS AND MODERN MAGIC

METALS
yesterday—
today—
tomorrow.

a fascinating ASM book

by Dr. J. Gordon Parr

This is a book for technician and student alike to enjoy—a story of metallurgical progress through the ages to the challenging problems of science that must be solved tomorrow. Enjoyable reading—an ideal gift.

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FINEST REFRIGERATION SYSTEMS

Compact, so units occupy minimum floor space . . . meeting the special needs of your industry with

Custom Engineered Design

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- Overload and under-voltage protection
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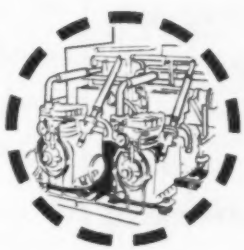

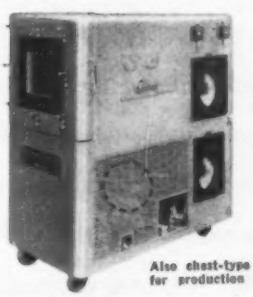

Also chest-type models for production chilling

Visit our Booth 1959, Metals Show, Philadelphia, October 17-21

CINCINNATI SUB-ZERO PRODUCTS

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Representatives in major industrial areas
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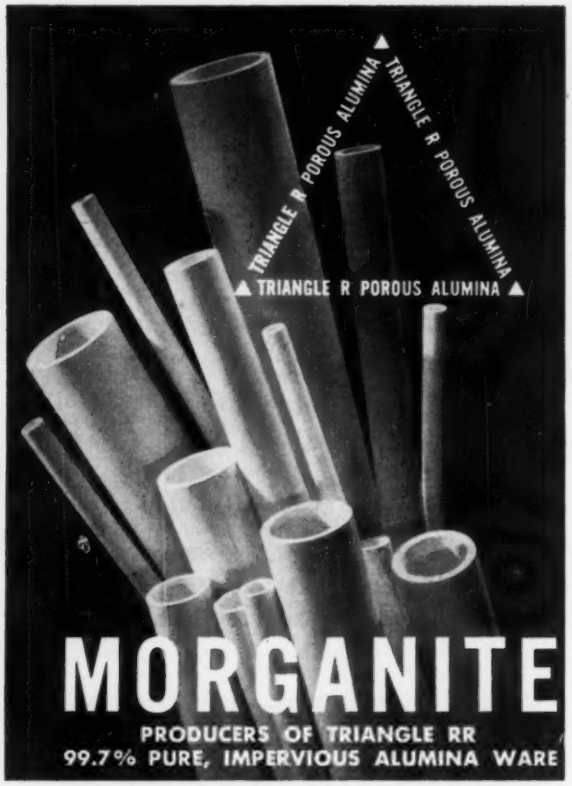

ANNOUNCES TRIANGLE R

POROUS, PURE ALUMINA TUBES

for temperatures up to 1900° C. (3450° F.) ® 99+% Al_2O_3 ® developed for use in hydrogen and cracked ammonia reducing atmospheres ® good electrical resistance at high temperatures ® porosity approximately 25% ® recommended for use with platinum, molybdenum or tungsten wound heating elements ® smooth, fine-grained alumina ® in sizes ranging up to 6" I.D. x 48"—available open both ends

Write for technical data, or call STillwell 4-3222

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Manufacturers of fine carbon graphite products including carbon specialties, motor and generator brushes, current collectors, etc.

Circle 1732 on Page 48-B

INGOT MOULDS AND STOOLS

Valley Mould and Iron Corporation
Hubbard, Ohio

●

Works:
Chicago, Illinois
Cleveland, Ohio
Hubbard, Ohio

Circle 1733 on Page 48-B

You ask for it—we'll send it!

New booklet tells all about GRAFO—the super-protector

Use GRAFO Water Products for high heat and excessive pressures, for press forging, extruding, etc. Use GRAFO Oil Dispersions for hammer forging, oven conveyors and general industrial applications.

▶ *Send for this booklet, explaining the proper graphite dispersions for specific operations. Use the coupon.*

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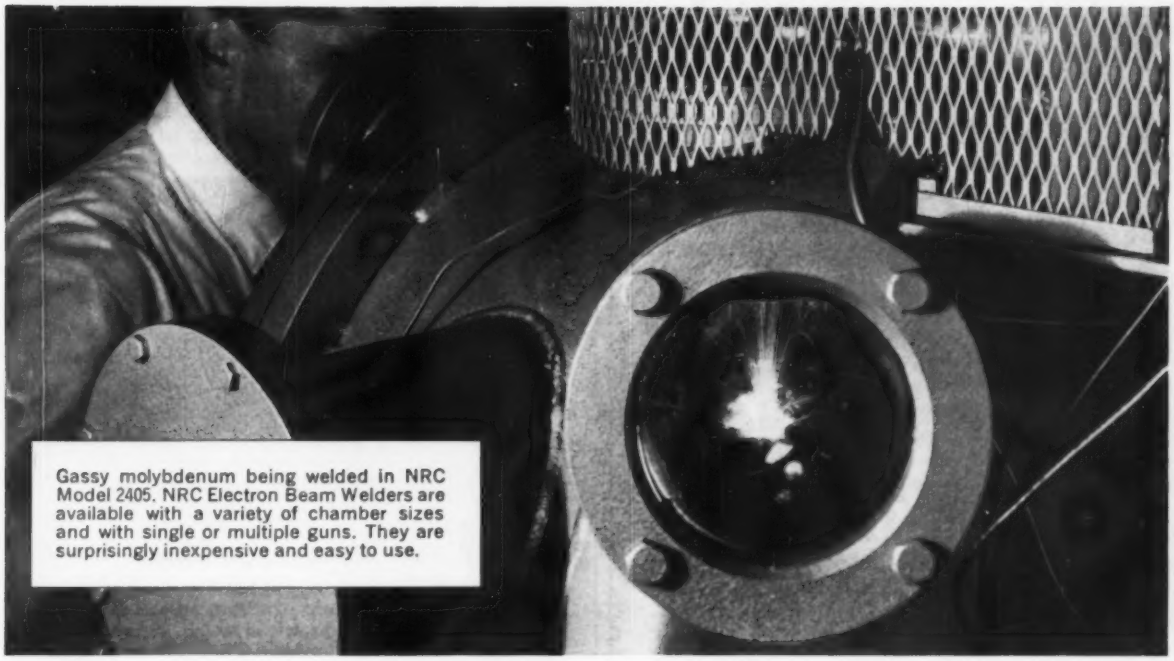
Circle 1734 on Page 48-B

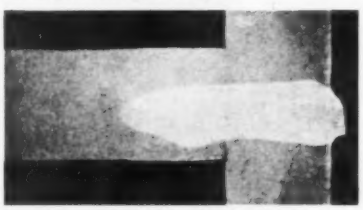


Gassy molybdenum being welded in NRC Model 2405. NRC Electron Beam Welders are available with a variety of chamber sizes and with single or multiple guns. They are surprisingly inexpensive and easy to use.

Can electron beam solve your tough welding problems?

What's So Wonderful About Electron Beam Welding?

Freedom from contamination; Minimum heat affected zone; Unlimited temperatures; Depth/width ratios to 4/1; Precise control of spot size and position; Operation in high vacuum. These advantages are daily solving problems posed by reactive metals, dissimilar materials, heat sensitivity, and unusual geometry.



Typical Solutions

- Inaccessible joints made by "continuous spike weld" (illustrated).
- Seam welded tungsten and tantalum tubes.
- Delicate instruments evacuated and sealed.
- Sintered plate welded without cracking.
- Finish machined parts joined without distortion.
- Precision bead at bottom of 1/16" slot.
- Titanium insert edge-welded to copper sleeve.
- Thin and thick sections joined easily.
- Crackless welding of glass-sealed feed-thru to sleeve.

NRC Small Lot Welding Service Gives Low Cost Answer

Here's a low cost, no risk way to find out if electron beam welding can solve your problems as successfully as it has those of others.

The NRC Small-Lot Welding Service was set up to prove that the Model 2405 Electron Beam Welder can indeed often "weld the unweldable." It gives you the chance to see exactly what the combination of superior equipment and experience can do with your problem welds. And, if you like, you can be your own operator!

The cost? NRC charges only for time and materials. Our prime interest is to help you discover whether electron beam welding is practical for your specific application.

Try The NRC Small-Lot Welding Service

The solution to your problem may be waiting for you right now at NRC Equipment Corporation. The sooner we hear about your application, the sooner we can tell you whether electron beam welding sounds practical, and, if appropriate, add you to our work schedule. Or, send for general information on Electron Beam welding and details on Model 2405, available for early delivery at less than $17,000.00.

NEO-25

NRC

EQUIPMENT CORPORATION

A Subsidiary of National Research Corporation

Dept. M-7, 160 Charlemont St., Newton 61, Mass.
DEcatur 2-5800

See Model 2405 in action at the Metal Show, Booth No. 1301.

ATOMIC AGE WHITESMITHS*

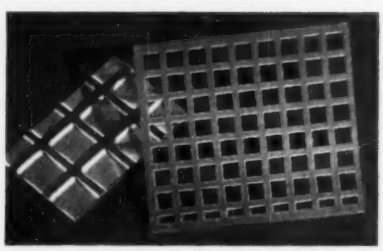
*Artisans in White, Rare and Precious Metals

SUPER ALLOY FORGE
INCORPORATED
JOHN E. CONNOLLY — ACADEMY 9-7860
HAMBURG, MICHIGAN

Circle 1735 on Page 48-B

NEW
DEEP-ETCH
MATERIAL FOR CHEMICAL MILLING

Kodak Metal-Etch Resist ... speeds up, simplifies, opens new chemical milling applications



This photo sensitive resist ends time-consuming handwork, allows close-limit accuracy in deep-etch weight reduction and parts manufacture. Also reproduces fine-line detail as in plating, dial and nameplate making. Withstands acids, alkalies, electrolytic fluids ... adheres well to aluminum, titanium, magnesium, stainless and other alloy steels. Makes volume production possible because of its high stability, strict uniformity. Send for detailed brochure: *Etching, Chemical Milling & Plating with Kodak Metal-Etch Resist.*

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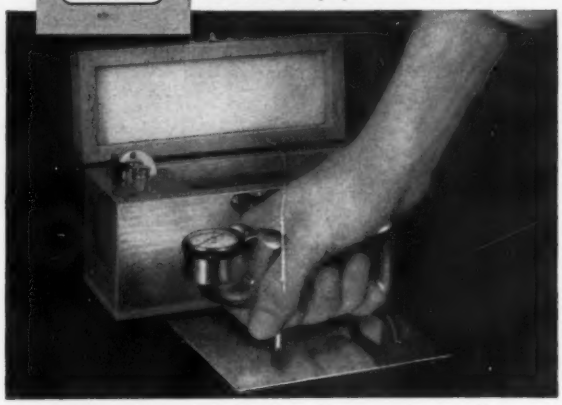
Kodak

Circle 1737 on Page 48-B

THE MARK OF QUALITY
BARBER COLMAN

Impressor
PORTABLE HARDNESS TESTER
- Rapid testing — no setup
- Easy to carry and use
- Needs only space for hand



A portable hardness tester for brass, copper, aluminum, other soft metals, and plastics, the Barber-Colman Impressor is designed for fabricated parts and raw stock testing. Operating experience is not essential. The reading is instantly indicated on the convenient dial. No waiting, preloading, or separate measurements. Barber-Colman engineers will gladly recommend the most suitable model for your application. Write today for complete details.

BARBER-COLMAN COMPANY
Dept. I, 1218 Rock Street, Rockford, Illinois

Circle 1736 on Page 48-B

PERECO Furnace
with
Kanthal Super Elements

for continuous operation at temperatures up to 2900° F.

"Provides the Higher Temperatures now needed in experimental fabrication and heat treating studies"

That's what one of the country's foremost research laboratories states when reporting on the use of their new Pereco Kanthal Super Element Furnace, illustrated above. Mounted on casters, this Model FGKS combines the accuracy and flexibility of heat control with the mobility of equipment so desirable in laboratory work. Tell us of your work requirement. One of Pereco's LINE of Kanthal Super Element Furnace might be just what you need.

Standard or Special Furnaces for temperatures of 450 degrees F. to 5000 degrees F.

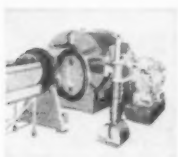
PERENY EQUIPMENT CO., INC.
893 Chambers Road, Columbus 12, Ohio
Department Q

PERENY EQUIPMENT COLUMBUS O

Circle 1738 on Page 48-B

Lindberg's exhibit at the ASM Show will have something of interest to anyone concerned with the application of heat to industry

Whatever your interest in industrial heating processes or equipment, we've carefully assembled material for our ASM Show exhibit to make sure that there will be something interesting enough to make your visit well worth while. Since Lindberg covers the entire field of "heat for industry" you can count on our coming up with helpfully informative ideas on all angles of this important phase of industry. If you are an old friend of ours we'll be happy to welcome you again. If you don't know all about Lindberg please come in and get acquainted. Here is a preview of some of the things we will be able to show and explain when you drop in:



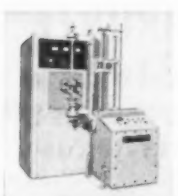
VACUUM HEAT TREATING FURNANCE

For example, you'll get information on vacuum heat treating, a complete picture of all types of vacuum heat treating furnaces and the advantages and specific uses of each. We know you'll be glad to be fully informed on this important method of metal treatment.

You will also be able to see and hear about the interesting developments we are making in the application of the new radiant wall heating principle to industrial heating equipment.

You will be interested, too, in a new development in Lindberg-Upton Salt Bath Furnaces. We call this the Cross-Channel Furnace, an entirely new concept of salt bath heating. This new type furnace provides a number of advantages: bottom heating; better salt circulation; inexpensive replaceable electrodes; long liner life; higher voltages; lowest salt absorption.

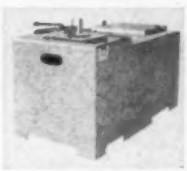
CROSS-CHANNEL SALT BATH FURNACE



HIGH FREQUENCY UNIT AND ZONE SCANNER

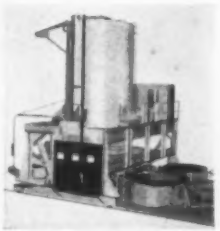
If you have not been aware of the developments Lindberg is making in equipment for the important semiconductor field, we will be able to bring you up to date at the exhibit. We will have there our newly developed horizontal zone refiner for purifying metallic germanium and full information on all our zone scanning equipment. You can learn about our gaseous and solid diffusion furnaces for basic research, pilot plant work or production of solid state devices. On display we'll also have a new conveyor type pilot plant furnace, ideal for small production heat treatment of metals and for alloying transistors and magnetic metals for the electronic industry.

One of the most interesting developments we will have on display at the show is a new idea in two-chamber induction aluminum melting and holding furnaces. This features a removable inductor section which will drastically reduce furnace down time when channel replacement is required. With this new development maintenance costs are also satisfyingly minimized as the need for complete furnace relining is greatly reduced.



TWO-CHAMBER MELTING AND HOLDING FURNACE

Possibly you are not familiar with the remarkable progress Lindberg Industrial Division has made in field erected installations. We will be pleased to show you many important complete installations of all types of industrial heating equipment and facilities where design, engineering and construction have all been handled entirely by Lindberg. Lindberg Industrial projects have covered all phases of plant design and construction, complete plants, production lines, integrated and automated equipment.



FIELD-INSTALLED GANTRY TYPE FURNACE AND FACILITIES

Anticipating your visit we will have a full representation of our top engineers and technicians on hand so you will be able to get full information on all of our new developments and also have an opportunity to discuss any of your specific problems with some of our experts. Please remember, too, that if you aren't able to see us at the show, you can always get help from Lindberg for your industrial heating requirements by getting in touch with your local Lindberg Field Representative (see your classified phone book) or by writing us direct. Lindberg Engineering Company, 2448 West Hubbard Street, Chicago 12, Illinois.

Los Angeles plant: 11937 S. Regentview Avenue, Downey, California. In Canada: Birlefco-Lindberg Ltd., 15 Pelham Ave., Toronto 9, Ont. Also, Lindberg plants in Argentina, Australia, England, France, Italy, Japan, South Africa, Spain, Switzerland and West Germany.

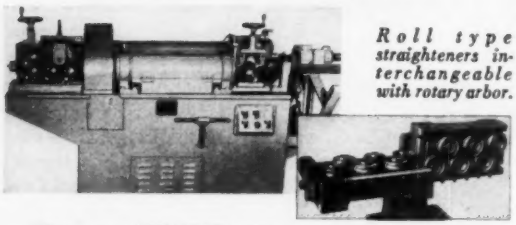
P.S. We almost forgot this important fact: You will find Lindberg at Booth 624 in the Convention Exhibition Hall.

LINDBERG
heat for industry

Circle 1739 on Page 48-B

If you use wire up to 3/8"

. . . this new SHUSTER is just for you!



Roll type straighteners interchangeable with rotary arbor.

These new SHUSTER wire straightening and cutting machines incorporate new advantages to give you higher production — for less cost. The 2ABV variable speed unit straightens and cuts round wire from 3/16" to 3/8"; the 2ABVF straightens and cuts shape stock up to 1/4" square.

The new machines include an improved, vertical drive 5-roll gear driven preliminary straightening unit, and feed roll housing, both Timken bearing equipped. The new SHUSTERS can automatically cut lengths up to 14" at the rate of 140 pcs./min. and provide infinite variable speed within all feed and cutoff ranges. This machine may also be purchased as a constant speed unit (150 F.P.M.).

METTLER MACHINE TOOL, INC.

153 Adeline St. New Haven, Conn.

Circle 1740 on Page 48-B

REVCO

ULTRA-LOW TEMPERATURE CABINETS

TEMPERATURES TO −140°F.

for

- Research
- Storage
- Seasoning
- Testing

Seven Revco cabinets, both chest and upright styles, are available. Capacities range from 1.5 to 6 cu. ft. in chests and to 22 cu. ft. in uprights. Units provide temperatures to −140° F. controllable within ±1°. Optional accessories are offered. Immediate delivery on all units.

For your FREE copy of the helpful folder, "Selecting a low temperature cabinet," write Revco, Dept. MP-100.

Industrial Products Div.,
REVCO INC.
Deerfield, Michigan
Setting Trends in Refrigeration Since 1938

Circle 1741 on Page 48-B

ACCURATE
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Circle 1743 on Page 48-B

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Circle 1744 on Page 48-B

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Circle 1745 on Page 48-B

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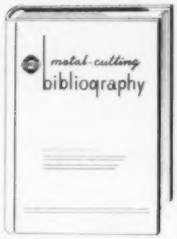

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Circle 1747 on Page 48-B

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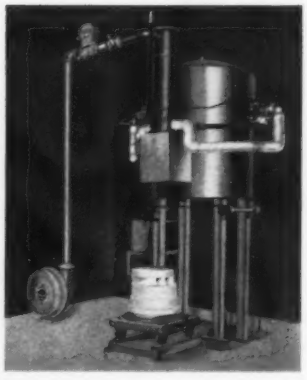

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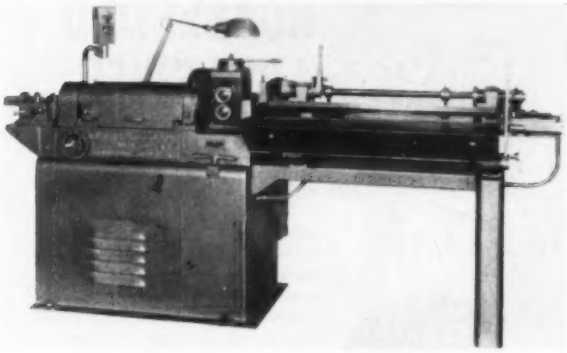

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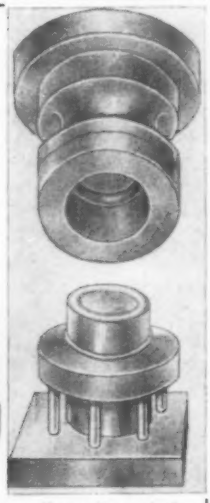

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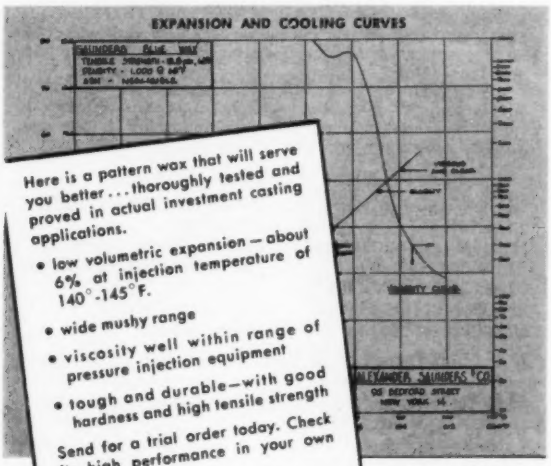

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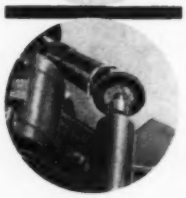

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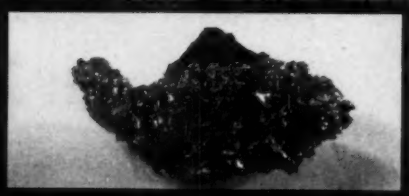

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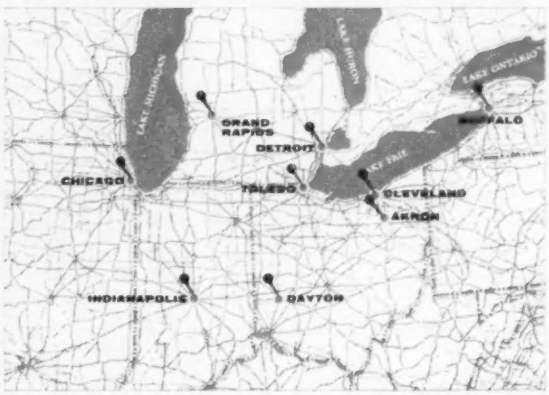

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Circle 1755 on Page 48-B

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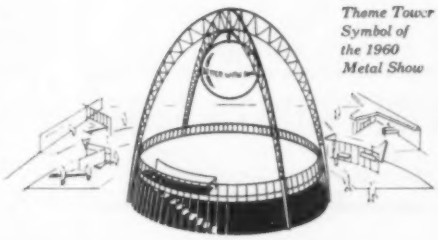

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BEHIND THE BYLINES

The comprehensive article on forming steels ("How to Make Better Drawings and Stampings") on p. 85 was written by Paul G. Nelson, superintendent of the production laboratory at the Budd Co. in Philadelphia. He joined the company's metallurgical staff soon after his graduation from the University of Cincinnati in 1940, becoming metallurgical supervisor in 1947 and supervisor of the production lab three years ago.

Although his technical affiliations include A.I.M.E. and A.W.S., he has been particularly active in the A.S.M.: He is past director of the Philadelphia Chapter, a former member of the transactions committee, a member of the Metals Engineering Program Committee, and chairman of the Handbook Committee on the Selection of Materials for Press Forming Dies. He has also played a major part in the success of one phase of A.S.M.'s educational program. For six years he has been co-director of A.S.M. metallurgy courses given at Temple University, and before that was an instructor.

Other interests include photography, gardening (with emphasis on roses), and in the more active line, golfing, hiking, swimming and the Boy Scouts. (His interests in the Boy Scouts is not surprising — of his seven children, four are boys.)

Nearly two years ago two articles on high-temperature metallurgy appeared in *Metal Progress* — one of the authors was L. P. Jahnke, manager of metallurgical engineering in General Electric's Flight Propulsion Laboratory Dept. This month Mr. Jahnke and E. S. Jones (shown in the photo on p. 130) cover some of the progress made in this area in the intervening months. A graduate of the University of Michigan (a B.S. degree and a M.S. degree in metallurgy), Mr. Jahnke has devoted ten years to research and development on materials and processes in high-temperature metallurgy — two years at the University of Michigan and eight in G.E.'s Flight Propulsion Div.

A graduate of the University of Kentucky (a B.S. in metallurgical engineering) and Ohio State University, Mr. Jones joined G. E. as a development engineer in the Research Laboratory working on a study of molybdenum alloys. In 1954 he became supervisor of

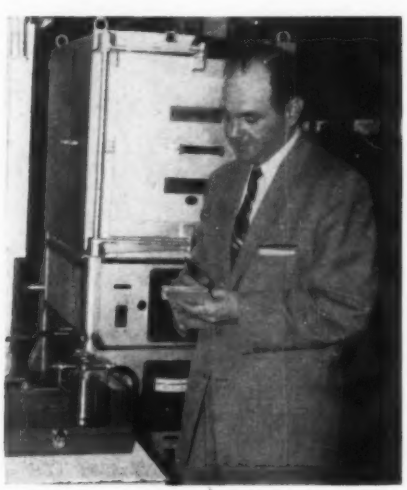
alloy development and for the past three years has been manager of alloy studies, covering the refractory metals, lightweight nonferrous metals and high-strength steels.

Mr. Jahnke's technical affiliations are many, including membership on the N.A.S.A. Advisory Committee on Materials and the M.A.B. Panel on Refractory Metal Sheet. Mr. Jones is on the Cincinnati Chapter Executive Committee and the High-Temperature Materials Committee of A.I.M.E. His major off-hour interest centers on his five children – with a little weekend gardening on the side.

The report on the vapor-shielded arc developed by Lincoln Electric (p. 96) is written by R. A. Wilson who, as vice-president, directs the company's application engineering department. Starting with Lincoln as a field engineer after his graduation from Cornell in in 1935, he later worked in the development laboratory and in 1950 took on his present job. During the past 25 years he has pioneered the application of arc welding in all phases of manufacturing, including tanks, pipelines and automobiles, to name but a few.

In recent years he also organized and directed Seminars in Welded Design dealing with the efficient use of welded steel in structural and machine design. As an added responsibility, he supervises the Lincoln School of Arc Welding.

The electronic quenchometer described on p. 111 was developed by the metallurgical section of the manufacturing staff division, General Motors Technical Center. The metallurgical section, which H. J. Gilliland supervises, works primarily on the development of new processes, equipment and metallurgical materials. A 1947 graduate of the Missouri School of Mines and Metallurgy, he joined G.M. in Kansas City, Mo., as an experimental metallurgist. This division produced both automobiles and the Republic F84-F Thunderstreak jet plane; he worked on aircraft operation and associated metallurgical developments until 1955 when he transferred to the manufacturing staff division in Warren, Mich.



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Circle 1758 on Page 48-B

Magnesium has been one of the main interests of James V. Winkler (see "Progress in Magnesium Alloys", p. 146) since graduation from the University of Michigan in 1941, with a B.S. degree in mechanical engineering. He went directly from the Ann Arbor campus to Dow Chemical Co.'s magnesium fabrication plant in Bay City and has been associated with magnesium operations ever since. He was transferred to the Los Angeles office as magnesium salesman, then

returned East in 1952, this time to Dow headquarters in Midland, Mich., as manager of the magnesium technical service and development group, a position he now holds with the Dow Metal Products Co. Div. formed last year. (He is shown above, left, with R. C. Forrest, group staff member.)

Four children keep him occupied after work, but when he can, he goes in for photography, woodworking, golf, bridge, hunting and fishing – he's ranged as far north as Canada's Montreal River for trout.

● ● ●

M. F. Garwood, chief engineer of materials for Chrysler Corp., discusses recent trends and future prospects in materials and process applications in the automotive industry on p. 114. A graduate of Ohio State University with a degree in chemical engineering and metallurgy, he worked as a metallurgist for International Harvester Co., and Inland Steel Co., then moved on to become chief of investigations for the South Works plant of United States Steel Corp. He joined Chrysler in 1941 as a project engineer, was promoted to chief metallurgist five years later, then assistant engineer, and finally chief engineer in 1955.

In A.S.M., A.S.T.M., S.A.E., and A.F.S. over the past years he has held both national and local chapter offices. His article stems from a talk he gave recently in Cleveland at a meeting of the A.S.T.M. in cooperation with A.S.M. and S.A.E.

Married, with two daughters and a son, he has several outside interests which he pursues "as diligently as time allows". Fishing is his major preoccupation (he's shown with rod in hand) and this includes making his own bamboo rods and tieing his own flies.

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